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ORIGINAL ARTICLES.

I.—Eminent Living Geologists.—No. 6.

Professor Archibald Geikie, LL.D., F.R.S. L. & E.,

DIRECTOR-GENERAL OF THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM.

(WITH A PORTRAIT.) [1]

DOCTOR ARCHIBALD GEIKIE was born in Edinburgh in 1835. He was educated at the Royal High School—the most famous of the many celebrated scholastic institutions of the "Modern Athens," and at Edinburgh University. He became an Assistant on the Geological Survey of Scotland in 1855, and in 1867, when that branch of the Survey was made a separate establishment, he was appointed Director. A few years later—in 1871—he was elected to fill the Murchison Professorship of Geology and Mineralogy in the University of Edinburgh, when the chair for these subjects was founded by Sir Roderick Murchison and the Crown in that year. Subsequently he resigned these appointments, when at the beginning of 1881 he was appointed to succeed Sir Andrew C. Ramsay, as Director-General of the Geological Survey of the United Kingdom, and Director of the Museum of Practical Geology in Jermyn Street.

It is hardly necessary to say that during this period he has engaged in an immense amount of official work. To begin with, he had the direct supervision of the Survey of Scotland almost from its commencement, and has mapped with his own hand many hundreds of square miles of country, besides writing or editing all the published Survey Memoirs descriptive of Scotland. Again, since becoming Director-General in London, he has given special attention to the petrographical department of the service, previously weak, but which has now attained great strength and importance. Professor Geikie was one of the first field-geologists in this country to perceive the importance of microscopic investigation as an adjunct to field-work, and to begin this investigation himself. One direct result of this has been the great enlargement of the petrographical collection of the Museum in Jermyn Street. Upwards of 5000 slides of British rocks have been prepared and are now available for the student in this branch of investigation.

The one-inch Geological Survey maps of England and of Ireland

[1] The portrait accompanying this Notice is most obligingly lent by George A. Ferguson, Esq., Editor of the "Mining Journal," in which periodical it appeared on December 28th, 1889, and from the columns of which this notice has been largely reproduced.—Edit. Geol. Mag.

have been completed during Professor Geikie's tenure of the Director-Generalship. The survey of the superficial deposits over those parts of England and Wales, where they are not previously mapped, is now being carried on. The Survey is at present also gathering up the results of its long labours in the form of descriptive Memoirs of each of the geological formations of the country.

Those who consider the work of the Geological Survey all very easy and plain sailing will probably change their views when we mention that, as a matter of fact, the maps of the Coal-fields and mineral districts have continually to be revised and kept up to date. Constant supervision, too, is necessary on the part of the Director-General in the field-work and office-work connected with the engraving of maps and sections, and the editing of the Memoirs.

Though Dr. Geikie's hands are very fully occupied with his official duties, he has yet found time to engage extensively in exhaustive original research. Amongst the more important investigations carried on by him over and above his official work, may be mentioned his "History of Volcanic Action in Britain." This he has developed in a series of papers wherein the volcanic phenomena of the Old Red Sandstone, Carboniferous, Permian, and Tertiary periods have been illustrated. He has also discussed in numerous papers, and more particularly in his "Scenery and Geology of Scotland," the subjects of denudation and the origin of scenery. His "History of the Glacial Period" gave the first systematic arrangement of the deposits of that period with reference to the probable series of events of which they were the records; while his "History of the Old Red Sandstone of Western Europe" is a laborious investigation, of which the first part is published, and the second part is far advanced. In the prosecution of these researches Dr. Geikie has travelled over much of Europe, and has also studied the broad features of the Geology of the United States and of Canada.

Dr. Geikie has long been intimately associated with the progress of educational work. He has always taken a deep personal interest in promoting the establishment of Natural Science as an instrument in Education. In this connection it may be mentioned that he is the author of primers of physical geography and geology, which have had a very large sale, and have been translated into most European languages, and even into some of those of India. He is also the author of some advanced class-books on the same subjects, of his well-known text-book of geology (now in its second edition), and of geological maps of Scotland and the British Isles.

When appointed in 1871 to the University Chair in Scotland specially devoted to Geology, Dr. Geikie had the whole work of that department to organize. He also prepared a large number of the diagram illustrations used in connection with his lectures with his own hand, and gathered together a valuable class museum.

Dr. Geikie has been largely engaged in literary work, as distinguished from purely scientific dissertation. In this connection it may be said that he has always recognized the importance of cultivating the literary element in scientific essay-writing. He has

been the author of many essays and reviews—signed and unsigned—in the leading reviews and journals. Some of these were selected and published in 1882 in a volume entitled "Geological Sketches at Home and Abroad." The main aim of these writings has been to make Science intelligible and interesting to those outside of the circle of actual workers. He has also written a number of biographical notices of his contemporaries published in "Nature," and in the Journals or Proceedings of scientific societies. Two larger biographies—"Memoirs of Edward Forbes" (in conjunction with Dr. George Wilson), and the "Life of Murchison"—the latter giving a sketch of the rise and progress of Palæozoic Geology in Britain, are also from the same prolific pen.

Those who are familiar with Dr. Geikie's style will, we feel sure, agree with us, that he is one of the pleasantest and most attractive writers of our time. His articles have adorned the pages of this MAGAZINE, since its commencement in July, 1864, and have always been most valuable and suggestive, whether they dealt with some special geological phenomenon, such as "the Old Man of Hoy;" "a volcanic bomb in the cliff at Burntisland," or with broad subjects such as subaerial denudation and the physical features and scenery of a country, or the volcanic phenomena of the British Islands.

In these and kindred subjects, Dr. Geikie has shown, not only the pen of the ready writer, but also the pencil of the accomplished artist, and doubtless much of the charm he possesses is due to the combined power to take in and fix rapidly with pencil, as well as graphically to describe, the salient features of the country he is traversing.

It is satisfactory to know that the continuous labour and scientific studies of Dr. Geikie have not passed without recognition. He has been elected into many scientific societies at home and abroad. He entered the Royal Society before reaching the age of 30, a most unusual honour; has been Vice-President, and was recently elected Foreign Secretary of that Society. Within the last few months the Berlin Academy has placed him in its ranks, the Royal Academy of Sciences of Göttingen has elected him to the vacancy caused by the death of the illustrious Studer—the Nestor of Swiss geology, and the Imperial Leopold-Caroline Academy—the oldest scientific Society of Germany—has enrolled him among its members. Dr. Geikie has also been the recipient of the Murchison medal of the Geological Society, and has twice received the MacDougal Brisbane Gold Medal of the Royal Society of Edinburgh. He is an Honorary LL.D. of the Universities of St. Andrew's and Edinburgh.

The Geological Survey of the United Kingdom has every reason to congratulate itself in having for its Director-General not only a practical geologist, but a gentleman so widely known and respected and of such scholarly attainments as Professor Archibald Geikie.

It is an open secret we believe, with most scientific men about London, that Dr. Geikie is the President-designate of the Geological Society, a choice which will be sure to meet with the cordial support and approval of all its Fellows.

II.—Mr. Mellard Reade's Interpretation of the Lower Trias Physiography.

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

IF truth is elicited by the conflict of opinion, we ought to arrive at a right conclusion as to the physical history of the English Trias. Unfortunately, however, some of the hypotheses propounded result, as it seems to me, from dwelling too much on certain minor difficulties, or limiting the view to one group of facts, while others not less important are excluded. From these objections Mr. Mellard Reade's interesting communication, printed in the Geol. Mag. for last December, does not appear to me exempt.

Incidentally, however, he clears the ground by his distinct recognition of the fact (often overlooked) that the Bunter and the Keuper were deposited under very different circumstances, and by the statement (grounded on personal observation) that the tripartite division of the Bunter group is not so general or so definite as was asserted by Professor Hull. This removes a difficulty in the hypothesis of a fluviatile origin, which I have always felt to be rather serious.

Restricting his remarks to the Bunter, Mr. Mellard Reade admits that the lake-delta hypothesis is unsatisfactory, and that the choice lies between a fluviatile or a marine origin.

His main objections to the former of these two hypotheses, as I gather from his paper, are the following:—

(1) That he cannot understand the existing distribution of the Bunter on the hypothesis of a fluviatile origin. He adduces some instances of his difficulties. Of these one only seems to me important, the occurrence of Triassic Sandstones in the Vale of Clwyd. Doubtless this is a difficulty, but I find it no more easy to account for these on the hypothesis which he prefers; so that I remain where I was. The patch of Trias, low down in the Eden Valley, does not seem so very anomalous, while I entirely fail to see any improbability in regarding the Pennine Chain as an upland which separated for a time the valleys of two rivers, draining the mountainous region to the north. As for the general tendency of the sandstones to thin off against the hills which bounded the Triassic lowland, that is no more than what we should expect, and agrees with the demeanour of the sub-Alpine drifts at the present day.

(2) That there is no instance on record "of the finding in Triassic Sandstones of anything like a river channel." I should be rather surprised if one had been detected. Rivers discharging sand and gravel on an open lowland, and liable to frequent floods, are constantly changing their courses, and the deposits are so variable that definite channels are not indicated. The same objection would apply to the great masses of post-Pliocene drift which border the Alps, and to the nagelflue and molasse of Switzerland.

(3) That "it is difficult to conceive of a river . . . . bringing down nothing but sand." The sub-Alpine drifts, just named, closely resemble the Bunter pebble-beds, and as regards thickness are not

unworthy of being compared with it. The nagelflue and molasse of Switzerland for a greater thickness than even the Trias of Bootle consist only of pebbles and sand. As I have more than once pointed out, the close resemblance of these deposits to the Lower Trias of the northern half of England indicates a similarity of origin; and though some marine deposits do occur in the Swiss Miocenes, I believe that the freshwater origin of the beds to which I refer is universally admitted.

(4). The disappearance of the northerly "plateau or Alpine range from which the materials of the Trias have been supplied. Why should it have been destroyed, when a lesser orographic feature like the Pennine Chain remains?" Mr. Mellard Reade does not appear to me to be quite consistent throughout his paper in regard to this objection; but letting that pass, I reply that the same kind of objection might be brought forward in regard to the Alps and the Jura. The former have lost by denudation much more than the latter. In fact, for very obvious reasons, of two mountain *massifs* in adjacent regions, the larger is likely to suffer more than the smaller. Further, in asking the question quoted above, Mr. Mellard Reade appears to have overlooked Scotland.

Having thus noticed Mr. Mellard Reade's chief objections to the fluviatile hypothesis, I will briefly mention one or two which occur to me against the marine alternative propounded by him.

(1) Even if we regard it as proved that "the tidal wave produces currents acting through the full depth of the water from the surface to the bottom," is there any evidence that these currents would be capable of sweeping about pebbles 3 or 4 inches in diameter—especially in Central England, where, in order to bring the tidal waves over the north-western region, the estuary should be pretty deep? Indeed, in Staffordshire (where I am writing), where evidence of deposit by powerful currents is very strong, pebbles of over 4 inches diameter are rather common. The Bunter here, *mutatis mutandis*, is identical with the drift bordering the Alps and with the Swiss nagelflue.

(2) Where, we may ask, can we place the communication between the Triassic estuary of North-west England and the open ocean? I venture to think that this serious difficulty has not been met by Mr. Mellard Reade, and that it cannot be brought with equal force against the advocates of a fluviatile origin for the English Bunter. A river can escape from open country through a narrow passage, but for a great tidal wave, competent to sweep to and fro, as he requires it to do, the gate must be wide and the way broad indeed.

(3) Have we any evidence to justify us in ascribing thick beds of conglomerate to marine action? Excepting cases where torrents discharge their contents into rapidly deepening seas—*i.e.* submarine deltas—can any instances be found of marine conglomerates comparable with such a deposit as the Bunter, which at any rate in some parts of England (as here) is a practically unbroken pebble bed at least thirty yards thick?[1] I have never myself read of or met with

[1] Generally, as stated by Prof. Hull (Memoir Triassic and Permian Rocks, p. 108, etc.), and, I fully believe, much more.

any such marine conglomerate, and, so far as I can infer from what I have seen of modern marine deposits, am led to belive that marine conglomerates are rather limited in extent and still more in thickness, under all circumstances but those which I have just mentioned.

I proceed lastly to the facts which Mr. Mellard Reade has overlooked.

(1) No notice is taken of the resemblance presented by the Bunter beds to the Alpine drifts, nagelflue, and molasse, or to parts of the German Trias, deposits for which a marine origin cannot be claimed.

(2) The origin of the Bunter pebbles is treated as if it were still a perfectly open question. "As regards the contained quartzite pebbles, one set of observers contend that they came from the north, another from the south, while a third considers that they have been derived from the destruction of rocks in Mid-England." I venture to think that this is hardly the case, unless (as appears to be the habit of some geologists) we regard a hypothesis which is a mere surmise as of equal value with one which is an induction from facts. Mr. Mellard Reade, moreover, is not even accurate in his statement of this problem. The "quartzites," though the most abundant, are by no means the only larger "materials of the sandstones." Of these it will be enough on the present occasion to mention three:[1]—

(1) Granites, gneissoid rocks and schists—rare and rotten—more resembling Scotch rocks than any other British, but too few and ill-preserved to give any conclusive answer.

(2) Various felstones, not rare. These as a rule cannot be identified with rocks from the Midlands, Wales, the Lake District, or Cornwall, but they exactly correspond with types of felstone which occur abundantly in Scotland.

(3) A peculiar quartz-felspar grit. This rock is identical with the Torridon Sandstone of Scotland, and certainly does not occur above ground in any part of England or Wales.

Next as regards the quartzites. First as to those containing fossils. These pebbles are very rare and different from the ordinary quartzites. They certainly are not unlike those of Budleigh Salterton, but they are also not unlike the fossiliferous 'quartzite' of the Lickey range (in the neighbourhood of which they seem to be rather more common). So that the evidence of these counts for little or nothing in the teeth of that mentioned above. Next in regard to the very compact hard quartzites, to which the majority of the pebbles may be referred (though vein-quartz—which does not help us much—is also abundant). The quartzite of these pebbles is not that of the Stiper Stones, the Wrekin, the Lickey or Hartshill; it is not any quartzite known to me as occurring in England. It is exactly like the quartzite of North-western Scotland, and identical pebbles occur in the newer Palæozoic conglomerates of the south-west of Scotland, the sandy matrix of which is often exactly like that of the Bunter.

I make these positive statements after long and careful study of

[1] Geol. Mag. Dec. II. Vol. X. (1883), p. 199.

the rocks to which they refer, and I challenge those who advocate a Southern or a Midland origin for the pebbles to point to localities within any probable distance where these rocks can be identified *in situ*.

Advocates of the former view must rest their whole case on the supposed identity of a few pebbles with those of the Budleigh Salterton conglomerate, and draw on their imagination for the home of more than 99 per cent. of the materials. Those of the latter must fly for refuge to hypothetical rock-masses concealed from sight beneath newer deposits. They, as it seems to me, will be driven to adopt Mr. Mellard Reade's hypothesis of a marine origin for the Bunter, because, as I have elsewhere pointed out, the rivers in this central region would not be long enough or powerful enough to round the pebbles. To them no doubt Mr. Mellard Reade's hypothesis will be tempting; but others, like myself, will wish to know how it can be accommodated to known facts before we can transfer it from the poetry to the prose of science.

III.—On *Phlyctænius*, a New Genus of Coccosteidæ.[1]

By Dr. R. H. Traquair, F.R.S., F.G.S.

(PLATE III.)

In the Geological Magazine for last month (January) I proposed to establish the genus *Phlyctænius* for the peculiar Coccostean from the Lower Devonian beds of Campbelltown in Canada, named by Whiteaves *Coccosteus Acadicus*. In this paper I propose describing that form more in detail, along with an allied, though at the same time very strongly marked species from the Lower Old Red Sandstone of Herefordshire, to which on that occasion I also referred.

Mr. Whiteaves apparently did not recognize the extent of the differences between this species and the true *Coccosteus* of the Scottish Old Red; but this I think he would have done, had he succeeded more thoroughly in deciphering the arrangement of the plates of the cranial buckler. As it is, he seems almost to hesitate as to whether it is specifically distinct from *Coccosteus cuspidatus* of Agassiz. "In some respects," he says, "the Campbelltown *Coccosteus* very closely resembles the *C. cuspidatus* of Agassiz, but in others there are such marked differences between the two forms that it is thought more prudent, for the present, to distinguish the Canadian species by a local name." He notices the similarity in the arrangement of its "superficial" (*i.e.* sensory) grooves, with those of *C. decipiens*, Ag., and finishes by saying: "It would seem, therefore, that *C. Acadicus* may be distinguished from *C. decipiens* by the different shape of the post-dorso-median plate, from *C. cuspidatus* by the different arrangement of the grooves on the outer surface of its cranial shield, and from both by the peculiar sculpture of its bony plates."[2]

[1] Read before the Royal Physical Society of Edinburgh, 15th January, 1890.

[2] Trans. Roy. Soc. Can. vol. vi. sect. iv. 1889, p. 93.

It is, therefore, evident that Mr. Whiteaves was unaware that *C. cuspidatus* is nothing but a mere synonym of *C. decipiens*, and that he also makes no allowance for the fact that Hugh Miller's figure on plate iii. of the "Old Red Sandstone," from which he seems to derive his information as to the characters of this supposed species, is only an imperfect restoration of *C. decipiens* executed at a time when our information in such matters was still rather undeveloped.

The cranial shield of *Phlyctænius Acadicus* (Pl. III. Fig. 1-2) must have been considerably vaulted from side to side, as the specimens, now much flattened, not unfrequently present irregular longitudinal fractures. The form is broadly ovate, truncated behind with prominent *postero-lateral* angles (P.L.). In front of the postero-lateral angle the margin passes obliquely outwards and forwards for a short distance, and then forms another obtuse angle, the *postero-external* (P.E.), succeeded by a shallow notch, in front of which is the antero-external angle (A.E.). Immediately after this the direction of the margin is forwards and slightly inwards to what may be called the post-orbital angle (P.O.), whence proceeding more strongly inwards, it forms a slightly excavated edge, evidently equal to the orbital excavation of the shield of *Coccosteus*, and bounded in front by the ante-orbital angle (A.O.). Between the ante-orbital angles of opposite sides, the margin of the shield is completed in front by a shallow concavity occupied in the perfect state by the "rostral" plate as shown by Mr. Whiteaves.

Leaving the sensory groove system out of consideration for the present, it is first to be noticed that the determination of the constituent plates of the buckler is a matter of extreme difficulty, from the fact that they are apparently all fused or anchylosed together in the manner in which those of the shield of *Pteraspis* are in the adult form supposed to be. Mr. Whiteaves has noticed the frequent arrangement of the tubercles in concentric rows, and this arrangement, much more marked in some shields than in others, along with the lines seen to radiate from the ossific centres in abraded specimens, first led me to suspect that the form and arrangement of the cranial plates differed in some material points from what is given in Mr. Whiteaves' sketch.[1] Close observation by means of a good lens enables one, however, also to observe the original lines of suture, due care being taken not to be deceived by fractures. Though the direction of these sutures is often indicated by depressed lines or slight grooves free from the tubercular ornament, yet the actual suture is not incised, but *slightly raised* like a very fine thread, this being due to the manner in which the original lines of separation between the bones have become entirely filled up by osseous matter.

The results obtained by noting these lines in connection with the concentric arrangement of the rows of tubercles being in all essential respects the same in all the specimens (six) which I have examined, and being furthermore in complete accordance with the information

[1] *Op. cit.* p. 93, woodcut.

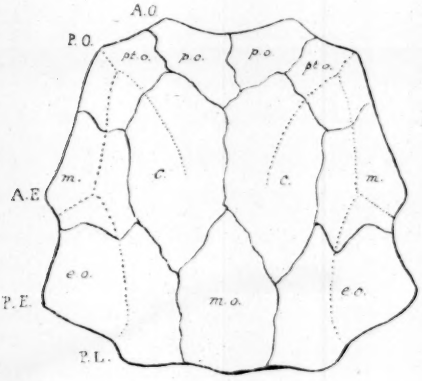


Fig. 1.

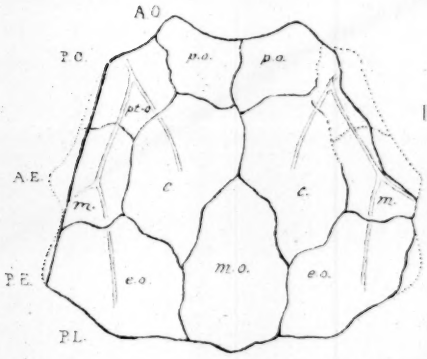


Fig. 2.

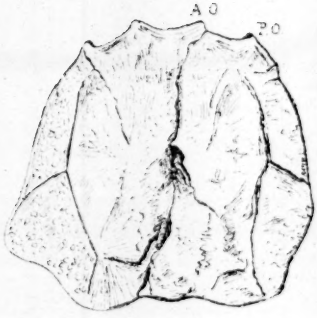


Fig. 3.

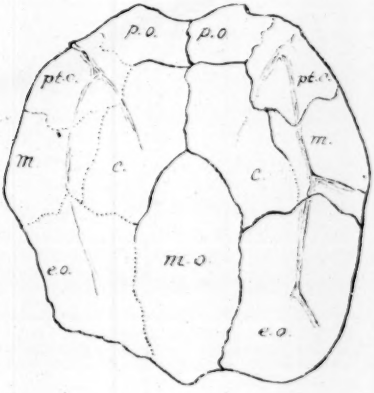


Fig. 4.

derived from the lines radiating from the ossific centres in a specimen with the surface rubbed off, there can be no doubt that the true form and arrangement of the constituent plates of the shield has been arrived at. The pattern in two shields has been represented in outline in Pl. III. Figs. 1 and 2, and if the reader will compare these figures with that which I have already given of the cranial shield of *Coccosteus*,[1] the fundamental agreement as well as the essential difference between the two will at once be perceived.

The *median occipital* plate (*m.o.*) is more or less five-sided, elongate, truncated behind, pointed in front, where it is wedged in between the hinder thirds of the two centrals. Its ossific centre is near the posterior margin, and is marked by a prominent elevation of the surface. On each side of the median occipital is placed the *external occipital* (*e.o.*), which, although differently shaped from that in *Coccosteus*, forms, as in that genus, the postero-external angle (P.E.) of the shield. In front of these three occipital plates, and occupying a position in the middle of the shield rather nearer the front than the back, are the two *central* plates (*c.*), whose difference of form from those of *Coccosteus* is equally striking, as is the case of the median occipital. They are more or less of an ovate-oblong, approximating to an elongated hexagonal form, articulating in the middle line with each other and round about with all the other plates of the shield except the rostral or anterior ethmoidal. The *marginal* plate (*m.*) is situated on the outer side of the central in front of the lateral occipital, and forms the antero-external angle of the shield (A.E.); in front of it is the post-orbital (*pt.o.*), which forms the post-orbital angle (P.O.), and the posterior part of the orbital margin. The front of the shield is now filled in by the pre-orbital plates (P.O.) which meet in the middle line, form the ante-orbital angle, part of the orbital margin on each side, as well as the anterior median shallow excavation, in which the plate named "rostral" by Whiteaves fits. This rostral plate is not present in any of the specimens in the Edinburgh Museum, but its form and position in the specimen figured by Whiteaves,[2] render it evident that it corresponds with the *anterior ethmoid* in *Coccosteus*.

Some amount of variation is observable in the form of these shields as well as of their component plates. Fig. 2 represents the configuration of a specimen which is proportionally shorter and broader than usual, and in which also the median occipital plate advances further forwards between the centrals, which are more irregular in shape, and have their long axes divergent backwards.

The arrangement of the lateral line system corresponds in the main with that in *Coccosteus*. The lateral groove commences on each side in the external occipital plate near the postero-lateral angle of the shield. Running forwards and slightly outwards, it passes on to the marginal plate, where it gives off a branch backwards and outwards to the edge of the shield just behind the postero-external angle. The main groove then turns forwards and slightly inwards at an obtuse angle, and on passing on to the post-orbital turns on the

[1] Geol. Mag. Dec. III. Vol. VI. Pl. I. Fig. 2.
[2] *Op. cit.* pl. ix. fig. 1.

middle of that bone acutely backwards and inwards, ending on or near the centre of ossification of the central plate. Just at the point where the backward turn commences, a short branch is given off which ends in the post-orbital angle or prominence.

Mr. Whiteaves represents the main groove as again continued forwards at an acute angle so as to end at the front of the shield near the ante-orbital prominence. Judging from analogy with *Coccosteus*, one might expect it to do so, but this continuation is not exhibited in any of the specimens which I have examined.

Associated in the same deposit with the cranial shields are found various other isolated plates, which from their sculpture probably belong to the same fish. Of these the only one which seems to be clearly identifiable is the median dorsal plate (Whiteaves, *op. cit.* pl. ix. fig. 2). The plate which he has figured as "left pre-ventro-lateral" (*ib.* fig. 3), if it is so, must belong to the right side of the body, but his "ventro-median (?)" cannot be referable to a median position as it is unsymmetrical. The Edinburgh Museum possesses a number of such detached plates of different forms, but I am certainly not prepared to speculate at present as to their position on the body cuirass. One thing is at least evident, namely, that if those plates really belong to *Phlyctænius*, their difference of form from those of *Coccosteus* certainly gives additional emphasis to the distinctness of the genus. No trace of the maxillæ or mandibles of *Ph. Acadicus* has, so far as I am aware, been yet discovered.

Phlyctænius Anglicus, sp. nov.

A good many years ago a small lot of fossils from Herefordshire was purchased from a London dealer for the Edinburgh Museum, and among them I found a small cranial shield, which, being obviously referable neither to *Cephalaspis*, nor to *Pteraspis*, nor to *Scaphaspis*, was rather puzzling in its appearance. Being, however, at the time specially engaged with other subjects, this shield, from Cradley, lay rather neglected, till one day I bethought me of it when examining our collection of fish remains from the Devonian rocks of Canada, and I was then greatly interested to find that the English fossil was in reality a Coccostean, and a Coccostean not of the type of *Coccosteus decipiens*, but of *Phlyctænius Acadicus*. This is of special geological interest, seeing that both in England and Canada this type is associated in the same beds with *Cephalaspis*, whereas not a trace of any Cephalaspidean has ever occurred in those northern Old Red Sandstone deposits (Orkney, Caithness, and Moray Frith) in which the typical *Coccosteus* is abundant. Nor does *Coccosteus* occur in Forfarshire, where *Cephalaspis* is characteristic.

At the time I made this discovery no one seemed to know of the existence of a Coccostean in the Cradley beds, though indeed a piece of the shield of this very species is figured by Lankester in his Monograph of the Cephalaspidæ (pl. viii. fig. 4) as a "fragment of doubtful character" in connection with *Zenaspis Salweyi*.[1] How-

[1] Mr. Wm. Davies seems to have believed in the occurrence of "Placodermi" in the Herefordshire beds, as he labelled some fragments in the British Museum "*Pterichthys*." They do not, however, belong to that genus.

ever, a short time after communicating with Mr. Smith Woodward on the subject, I received a letter from that gentleman informing me that he had since discovered, in the stores of the British Museum, quite a number of specimens apparently identical with that to which I had referred. He also kindly forwarded to me a plaster cast of one of them, as well as outlines in pencil of two others.

In Pl. III. Fig. 3, I have given a sketch of the specimen in the Edinburgh Museum. It measures $1\frac{3}{4}$ inches in length, and in general form resembles the cranial shield of *P. Acadicus*, except that at the back it is more produced outwards, as in *Coccosteus*, the postero- and antero-external angles being confluent into one of considerably greater prominence. In front we have the same more anterior direction of the orbital excavations, bounded by the post-orbital and ante-orbital prominences, and between the latter (of each side) we have a similar gentle concavity for the rostral or ethmoidal plate.

It is the internal or concave aspect of the shield which is here exhibited, and it is extremely difficult to recognize any sutures except that separating off the median occipital, which shows distinctly enough that this plate had the same elongated pointed form as in the Canadian species. The bone being considerably splintered away, especially on the right side, some of the external markings are seen in impression, showing that the surface was sculptured with tubercles of a comparatively large size. The course of the lateral-line groove may be distinctly enough seen, its disposition being quite similar to that in *P. Acadicus*,—the main groove, starting in the external occipital, passing obliquely forwards and inwards to the ossific centre of the plate, then proceeding forwards and slightly outwards for a little distance, and sending a branch obliquely backwards and outwards to the external angle of the shield, after which it proceeds forwards and slightly inwards to behind the postero-orbital angle. There, a ridge on the inner surface of the shield indicates that it turns at an acute angle backwards and inwards to the middle of the central plate in a manner quite similar to that already seen in *P. Acadicus*. .

Figure 4 is a diagram-sketch of the plaster cast sent me by Mr. Smith Woodward, taken from a specimen which clearly belongs to the same species, and which shows many points with greater clearness than that belonging to the Edinburgh Museum, the outer surface being here displayed. It measures two inches in length by two in breadth, but has a piece broken off at the posterior part of the left side, while on the right it looks as if the prominent external angle were covered by the matrix. The surface is covered by a coarse pustular tuberculation, omitted in the figure, showing at places a little, but not much, of the concentric arrangement; the course of the lateral-line grooves is clearly discernible, while the form and arrangement of the constituent bones may be pretty fairly made out, both by actual indications of sutures as well as by radiating lines where the surface has been abraded. It is clear also, from both specimens, that these bones were quite

fused or anchylosed together, and in the cast now under description the sutures are sometimes indicated by delicate raised lines as in *Ph. Acadicus*. I have indicated in the sketch the course of the divisions between the plates, naturally in a somewhat exaggerated manner, as the lines themselves are only visible by a lens and often cannot be followed at all. But from what is seen it is quite clear that the plates were quite similar in general form and arrangement to those in *P. Acadicus*, and especially to those in the specimen represented in Fig. 2, the median occipital extending far fowards and the centrals being rather truncated in front.

One of the pencil outlines sent to me by Mr. Smith Woodward shows apparently the rostral or ethmoidal plate in situ, thus completing the generic resemblance between the Canadian and English species.

We may therefore sum up the results of the preceding investigations as follows:—

Genus *Phlyctænius*, Traquair. Cranial shield more ovate than in *Coccosteus*: constituent plates anchylosed, except the ethmoidal; median occipital elongated, pointed in front and wedged in between the posterior ends of the oblong or ovate central plates; orbital excavation looking more anteriorly than in *Coccosteus*; course of main lateral-line groove nearly straight from the external occipital to the postorbital, where it is very acutely bent backwards. Plates of body-cuirass imperfectly known.

1. *P. Acadicus*, Whiteaves sp. External angle of cranial shield divided by a shallow notch into two, the postero- and antero-external angles; surface ornamented by fine tubercles, in most specimens showing a concentric arrangement parallel to the margin of the constituent plates. Lower Devonian, Canada.

2. *P. Anglicus*, Traquair. Postero- and antero-external angles confluent, surface covered by a coarse pustulation. Cornstones, Herefordshire.

In conclusion my most hearty thanks are due to Mr. Smith Woodward for the information he has afforded me regarding the Herefordshire specimens in the British Museum, and to Dr. Woodward, F.R.S., for permission to make use of the plaster cast taken from one of these specimens.

EXPLANATION OF PLATE III.

In all the figures the same letters refer to the same things.

P.L. postero-lateral angle. P.E. postero-external angle. A.E. antero-external angle. P.O. postorbital angle. A.O. ante-orbital angle. *m.o.* median occipital. *e.o.* external occipital. *c.* central. *m.* marginal. *pt.o.* post-orbital. *p.o.* pre-orbital. *e.* ethmoidal.

Fig. 1.—Restored outline showing the arrangement of the plates and lateral-line grooves in the cranial shield of *Ph. Acadicus*, Whiteaves sp.

Fig. 2.—The same in another specimen, lateral margins of the shield restored in dotted outline.

Fig. 3.—Sketch of a specimen of the cranial shield of *Ph. Anglicus*, Traquair, from a specimen in the Edinburgh Museum.

Fig. 4.—Sketch of a plaster cast of another specimen, contained in the British Museum, the surface ornament being omitted.

IV.—On a New Locality for the Arctic Fauna of the "Basement" Boulder Clay in Yorkshire.[1]

By G. W. Lamplugh.

Introduction.

DURING the course of a systematic investigation of the drifts of Flamborough Head, I have somewhat unexpectedly come across a fragment of marine Arctic beds enclosed in Boulder-clay, similar to those which form the well-known fossiliferous deposits of Bridlington and Dimlington;[2] and as this occurs under very different conditions from those already described, it adds materially to our knowledge of the beds, and illustrates more clearly their origin.

The newly-discovered bed lies in the face of the cliff on the east side of a shallow recess in the southern coast-line of Flamborough Head, known as "South Sea Landing." This place is within half a mile of the village of Flamborough, and is about four miles north-east of Bridlington, the latter being the nearest previously known locality for the beds.

The chalk on both sides of this recess forms vertical cliffs below the drifts, varying from 60 to 80 or more feet in height; but here, having been excavated in pre-Glacial or early Glacial times, it sinks suddenly to the sea-level.

The hollow thus formed has a breadth of about 300 yards, and is bounded on the west side by an abrupt cliff of chalk. On the east side the surface of the chalk shows a more gradual incline, but I believe that this is a deceptive appearance due to the line of section running at a very low angle to the scarp, and cutting it very obliquely, since a close examination of the drifts shows that they are banked against a very steep slope.

On the west side, the old valley-floor, standing two or three feet about high-water mark, extends from the cliff of chalk for 60 or 70 yards in a very gently sloping terrace which is strongly suggestive of a tidal flat, but toward the eastern boundary of the hollow the chalk floor sinks below beach-level.

This old hollow has been entirely filled in by drift deposits in Glacial times, but since that time a puny stream of surface water, which drains to the beach, has cut a narrow V-shaped ravine through the midst of the drifts. The sea has also eaten back further into the coast-line than where the chalk stands higher, and has thus formed the little recess of the South Sea Landing in whose nearly vertical cliffs, from 100 to 125 feet in height, most excellent sections of this curious infilling material are revealed.[3]

[1] Read at the Brit. Assoc. Newcastle, before Section C (Geology), Sept. 1889.

[2] For description of the Bridlington and Dimlington beds see Clement Reid's Survey Memoir on Holderness, pp. 8–26, and my papers in Geol. Mag. Dec. II. Vol. VIII. pp. 535–546, 1881; and Q.J.G.S. vol. xl. p. 312, 1884.

[3] These sections have already attracted some attention from geologists, and are mentioned by J. Phillips, Geol. of Yorksh. pt. i. 3rd ed. p. 91; T. Mellard Reade, A Traverse of the Yorkshire Drift, Proc. Liverpool Geol. Soc. 1882–3, p. 11; Wood and Rome, Q.J.G.S. vol. xxiv. p. 180; and J. R. Dakyns, Proc. Yorks. Geol. and Polyt. Soc. vol. vii. p. 249 (1880).

I do not propose in this paper to enter into the intricacies of this section further than is necessary to explain the relations of the shelly sand, leaving for some future occasion the discussion of the drifts as a whole. The accompanying section (Fig. 1), as seen in the cliff on the east side of the recess, will give some idea of the character and complexity of these deposits; and a few words of description will also be necessary. Between this and the opposite side of the hollow there are, however, considerable differences, the west side showing a much greater development of Boulder-clay, and a corresponding diminution in the thickness of the stratified beds which there lie tolerably evenly, and chiefly below the mass of the clay. (See Fig. 1.)

The Section.

The chalk-rubble (1) which rests on the chalk in this section differs only slightly from that which forms the base of the drifts nearly everywhere on the headland, but is of unusual thickness, and is distinguished by the presence of well-marked bedding-planes. Its thickness in the middle of the valley may, however, be more apparent than real, as I think it very probable, as suggested above, that we may be looking towards a hidden wall, or very steep slope, of the solid rock against which this rubble is banked.

The curving and steeply-sloping planes of stratification of this deposit look like cross-bedding, but are not of the normal character. Instead of sloping parallel to one another as in ordinary cross-bedding, most of the bedding planes converge downward, in sweeping curves, upon one horizon. This appearance, again, may possibly be due to the obliquity of the section.

The manner in which, on the west side of our section, the upper part of this rubble ends up against Boulder-clay, and on the east passes into it, shows that the rubble must in some degree have been formed contemporaneously with the clay. The occasional presence in it, also, of erratic blocks of large size, and the broken character of the chalk surface below it, point to a glacial origin; but its bedding and its connection with thick masses of sand and silt (1*b*) between *B* and *A*, show that it can scarcely be considered as true bottom-moraine.

I may briefly state that I think it has probably accumulated in the hollow between the glacier and the old cliff before the advancing ice had yet over-ridden the chalk; but to show clearly how this may have taken place would need a longer disquisition on the general character of the drifts than I propose now to make.

The lowest Boulder-clay (2) is seen as a tolerably solid mass on the south-east side of our section (Fig. 1), and it is even better developed on the headland immediately to the eastward. But if it be traced in either direction, it loses its massive character and shows a disposition to include irregular and contorted threads, veins or patches of stratified beds (2*a*). These stratified beds consist of sand, silt, gravel, clay, or even occasionally, though not in the immediate vicinity of this section, of transported Secondaries. These inclusions are of all shapes and sizes, and it is often difficult to define their

boundaries in the clay. Though the Boulder-clay itself generally contains many shell-fragments, the inclusions are as a rule unfossiliferous; it is an exception to this rule (2*b*) which it is the proper object of this paper to describe.

To finish my description of the section, the above-mentioned Boulder-clay generally rests directly on the chalk-rubble, as shown on the right in my section; but towards the centre of the South Sea Landing its base rises higher so as to admit the intervention of thick sandy and silty beds (1*b*) that seem at first to be interbedded with the rubble. The Boulder-clay thins out over these, till it finally disappears, and the stratified beds above and below it then come together for a short space as shown at C.

This thinning out evidently takes place in a north-easterly direction, as is shown by the reappearance of the clay after we turn the angle of the bay at *C*.

Above the shelly Boulder-clay lies a thoroughly-washed gravel (3), with regular bedding well brought out by sandy seams. It differs from the lower stratified beds in containing a very much larger proportion of foreign pebbles, some of them of large size; and indeed in many places it includes scarcely any chalk. Its thickness varies considerably, changing even within the limits of my section from 2 to 12 feet, while half a mile away on the opposite side of the Landing, at Beacon Hill, the cliff section cuts across a mound of sand and gravel about 80 feet thick, which I believe to be an exaggerated local development of this same gravel.

Shell-fragments, small and well-rounded, may be detected in it, but I look upon these as being as much "pebbles" as are the fragments of Liassic and other fossils which it also contains. It is evidently a re-assortment of the Boulder-clay material, either derived from the denudation of the clay, or, more directly, from the laving of the ice which carried and formed that bed.

Capping the section we have a thick mass of brownish Boulder-clay (4), much more homogeneous in character than the lower bed. The thickness of this clay is about 25 feet, but in one or two places a band of pebbles (4*a*) occurs 6 or 7 feet from the top of the cliff, which may indicate a line of division.

This upper clay is perhaps on the whole the most constant factor of the Glacial series of Flamborough Head, though it thins away and disappears in one or two places, as over the flanks of the above-mentioned great sand and gravel-mound at Beacon Hill.

The Shell-bed.

I will now revert to the mode of occurrence of the shell-bed. The chief portion of the fossiliferous deposit takes the form of an irregular lenticular seam of greenish-yellow sand, about 24 feet long and at its thickest part not more than four inches thick. This bed is curiously crumpled and twisted among the surrounding clay, and at either extremity it is drawn out into a mere contorted thread.

The accompaning figure (Fig. 2), in which a part of the section shown in Fig. 1 is enlarged, is intended to bring out these features.

As shown above, other irregular beady streaks of similar sand occur both above and below the main seam, but these are quite of minor consequence, and, when traced, are found to fall into the larger bed.

Surrounding these sandy seams there is a variable thickness, from 15 to 40 inches, of tenacious blue or greyish clay which differs in many respects from the Boulder-clay which borders it. It carries very few pebbles, and, though full of shearing-planes, shows distinct traces of stratification and lamination, and is altogether clearly an aqueous deposit.

Similar clays are also found at Bridlington and Dimlington associated with the sandy shell-beds, and sometimes themselves bear shells. These I regard as glacial muds formed on the same sea-bottom as the shelly sand, and probably in sequence with it, which have been removed and carried forward along with the sand. In former cases I thought the clay had been deposited before the sand,[1] but in this instance the beds have been rolled over and folded upon themselves, and it is impossible to make out their original arrangement.

Besides shells, the sand contains a few small, well-worn pebbles, not generally larger than beans, and these are not chalk or flint, but usually of a dark, close-grained igneous rock, or otherwise of yellow quartz, though many other varieties are present. The sand itself is chiefly made up of rather coarse quartz-grains, and altogether the bed is not of such a nature as would be likely to form on a floor of chalk.

A neighbouring streak, containing many crushed shells, consists almost altogether of these small dark pebbles, with but little sand.

The state of preservation of the shells deserves especial attention, as there is in this case such unmistakable proof that the bed has been transported bodily, and has undergone a considerable amount of shearing during the process.

In the minor streaks the shells are always reduced to fragments, and in the main seam also the majority are broken, though not so shattered.

In this seam, however, a small proportion occur in perfect condition, the bivalves even in some cases having their valves united. I obtained many specimens of *Astarte compressa*, which is the commonest fossil of the bed, in this condition, and also of *Astarte borealis*, some fine examples of the latter measuring over an inch across the valves.

When the shells are broken, the fragments occasionally still lie close together, though oftener they have been trailed apart during the shearing of the bed. As showing the effect of this shearing, it is most interesting to find instances in which the two valves of an *Astarte* have been displaced or separated without fracture, thus clearly proving a differential motion. These specimens also illustrate a curious feature noticeable in the Boulder-clay, wherein detached valves of various species may be found retaining a small pinch of sand under

[1] Q.J.G.S. vol. xl. p. 317.

the umbo, even when the Boulder-clay shows no other sign of the demolition of sand-beds. Until now I have found it difficult to understand the preservation of sand in such a position, but this difficulty has been cleared away by specimens which I have collected from the edges of the deposit under consideration. These show how one valve lying near the borders of a sandy seam may be driven forward into the clay by a lateral squeeze or push, carrying with it the sand which lay sheltered under its edges, while the other valve may remain imbedded in the sand. And when once a valve is thus incorporated with the clay, the sand under the umbo is effectively plugged in by the clay, and it is easy to understand how it may remain there if the shell remain intact, notwithstanding any further motion the mass of the clay may undergo.

Thus, I collected unbroken specimens of *Astarte compressa* often where the sand seam was so thin that both valves were nearly touching the clay, in which, though the valves remained in contact, they were twisted about so that the umbos did not coincide; others in which one valve had been pushed forward so as to touch the other at one point only; and others again in which the valves were quite separated; and in more than one case one valve with its contained sand had been so far displaced as to lie in clay.

It is somewhat curious to note that in the main seam the shells had suffered most where the sand was thickest, and that unbroken specimens were more common toward the extremities, where the seam was tapering out, than in the centre.

The following is a list of the species I have obtained from the bed. All these species occur also both at Bridlington and at Dimlington. The list is small as compared with the list of over 100 species from the former place; but this we might expect from the very limited nature of the seam, which can only represent one small portion of the sea-bottom, whereas at Bridlington not only were the patches of larger size, but they also showed great diversity and had evidently been brought together from different areas.

List of Species found at South Sea Landing.

c *Pecten islandicus*, Müller.
Mytilus modiolus? L.
Leda (*limatula*, Say?).
Cardium groenlandicum, Ch.
c *Cyprina islandica*, L.
c *Astarte borealis*, Ch., and vars.
c —— *compressa*, Mont.
—— ——, var. *striata*.
—— *sulcata*, Da Costa.
Mya truncata, L.
Mya truncata, var. *uddevallensis*.
Saxicava norvegica, Spengler.
—— *rugosa*, L.
c *Dentalium striolatum*, Stimpson.
Turritella erosa, Couth.
Natica islandica, Gm.
Fusus despectus, L.
Admete viridula, Fabr.
Balanus (*crenatus*?) Brug.

c indicates that the shell is plentiful.

Almost everywhere on the headland the Basement Boulder-clay contains a plentiful sprinkling of broken shells, which, along with the sea-worn and *Pholas*-bored pebbles, are doubtless derived from the complete destruction of beds such as these. But it is worthy of note that, as in former instances, while in the clay *Tellina*

Balthica is by far the commonest shell, it is not found in the sand-seam ; and on the other hand that, though *Astarte compressa* is so abundant in the sand, it is rare in the surrounding clay.

It appears as though the shallow-water and shore-line beds in which *Tellina* abounded have been more thoroughly obliterated than the deeper-water deposits where *Astarte* and *Dentalium* lived.

In this new locality, though the shell-bed itself is so limited in extent, it possesses one great advantage over the previously-known exposures, which causes the section to possess a peculiar interest; for whereas up to this time the shelly patches have always been found either at the foot of the cliff or on the beach, so that nothing could be learnt as to what lay below them, at South Sea Landing the fossiliferous bed is exhibited in section, and we see the whole of the drift series resting on chalk.

It has been thought possible in the previous instances that beds similar to the inclusions might occur undisturbed lower in the section; but in the new locality we see plainly that the stratified sand, silt, and gravel which underlie the Boulder-clay containing the shell-bed have nothing in common with the inclusions, and are quite unfossiliferous. Neither in the stratified bed which overlies the shell-bearing Boulder-clay is there any sign of contemporaneous fauna, the few worn shell-fragments to be found therein being evidently mere pebbles.

We have thus now, not only clear proof that the shells did not live where they now occur—a supposition which every feature of the section makes it unnecessary to discuss,—but also evidence to show that they are truly transported boulders, and have not been derived from the destruction of beds which existed in the immediate locality, for we find that no shell-bearing beds occur anywhere in place in these sections.

Origin of the Shell-bed.

That the formation of the Boulder-clay containing this shelly sand has been the work of land-ice which filled the basin of the North Sea and encroached upon the land, I have little doubt; but as to the exact mode in which the sand has been transported I confess I can form no clear conception.

The work of the ice in this part of the country seems chiefly to have been in the spreading out of successive pavements of clays and gravels, and it is only here and there that we find proof of its erosive influence. Consequently while I can understand well enough how a glacier advancing over a sea-bottom on which lay deposits of sand and clay might churn these up and mix them with its own debris in passing over them, thus manufacturing such a mass as the Basement Clay, I do not see how the sea-bottom could be dragged *under the ice* for long distances and raised to higher levels. Indeed, I think that all the evidence goes to show that the shelly masses when transported were actually *embedded in the ice*, and that their journeying has been exactly analogous to that of the solid boulders. But how they came to be lifted upwards so as to

attain to this position in the ice I cannot understand. I am sometimes inclined to speculate on the effect of "anchor-ice" forming in water of some depth at or under the edge of an advancing or gradually thickening ice-sheet, which, buoying up portions of the sea-bottom, might become affixed to the glacier as part of its mass and be driven forward with it; but this is, of course, mere guesswork.

But however carried, the curving lines and scattered shells of the included bed show that it has, either during or after its transportation, been rolled out and sheared by the passage of a heavy mass above it, and we can see that had the movement gone on a little longer, the clays and sands which now appear as streaks and patches would have become completely merged into the mass of the Boulder-clay. In fact, at this spot we study the Basement Boulder-clay in a state of arrested development.

It has frequently been noticed that the shells found in the drift deposits of the Western side of England indicate a warmer climate than those found on the Eastern side, and this has sometimes been quoted as evidence that the beds were not synchronous. But if it be taken as proved that at a certain period the Scandinavian ice-sheet coalesced with that of Scotland, then during that period whatever portion of the North Sea remained to the south of the ice must have been practically severed from the warm Atlantic and converted into an inclosed basin almost surrounded by ice-cliffs, wherein we may well imagine an Arctic fauna could establish itself. But during the same period the currents of the great Atlantic would preserve the more temperate fauna comparatively unaltered on our western shores.

This fact of the destruction of a glacial sea-bottom, and the incorporation of its material in the mass of the Boulder-clay, must not be lost sight of, as Clement Reid points out,[1] in studying the distribution of boulders in our Eastern Counties drifts. Under such circumstances the mere presence of fragments of Scotch, Scandinavian, or Baltic rocks in the clay cannot alone prove, as it seems sometimes to be taken as doing, that an actual flow of the ice has passed from those localities to the spot where the boulder is found.

During the encroachment of the glaciers there must have been a long period when the North Sea was crowded with ice-bergs and floe-ice, and these, floating hither and thither at the mercy of wind and tide, would scatter their blocks indiscriminately, and bring about much "intercrossing of erratics."

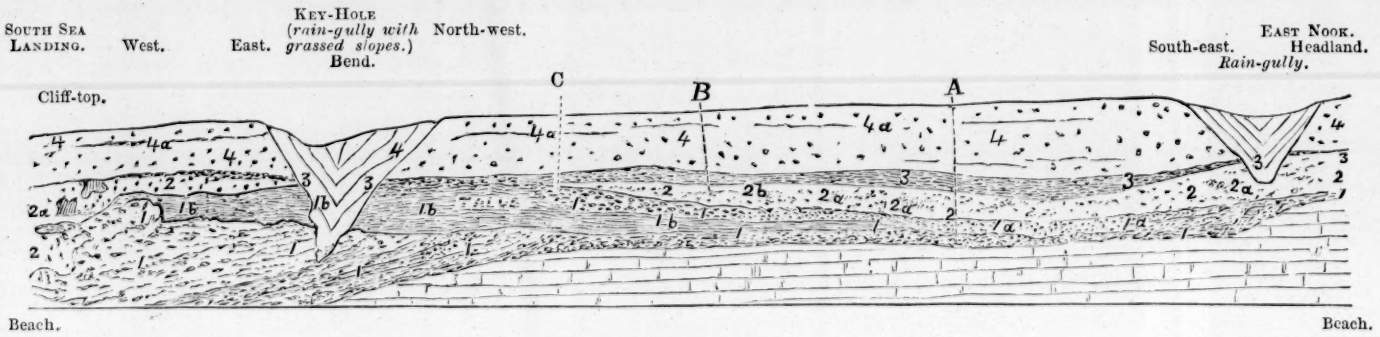
Thus at any one spot there might be brought together boulders from all parts of the catchment-area of the basin, and these, when the land-ice reached the spot, might be incorporated in the resulting Boulder-clay just as the shelly sands have been. Indeed the presence of innumerable *Saxicava*- and *Cliona*-bored stones and well-rounded beach-pebbles in the clay proves that many of its boulders have thus been derived.

Another point of interest in connection with this section is that

[1] Survey Memoirs: "Cromer," p. 90, and "Holderness," p. 43.

FIG. 1.—SECTION OF THE CLIFF ON THE EAST SIDE OF SOUTH SEA LANDING, FLAMBOROUGH HEAD.

Scale: 120 feet to 1 inch. Length of section: 290 yards. Average height: 125 feet.



EXPLANATION.

4. Brownish Boulder-clay: a band of pebbles, 4*a*, in places about 7 feet from the top.

3. Washed gravel, with thin sand-seams: well-bedded: pebbles chiefly erratics.

2. "Basement" Boulder-clay, with many included patches of sand, gravel, and silt, 2*a*: at B one of these 2*b* contains shells.

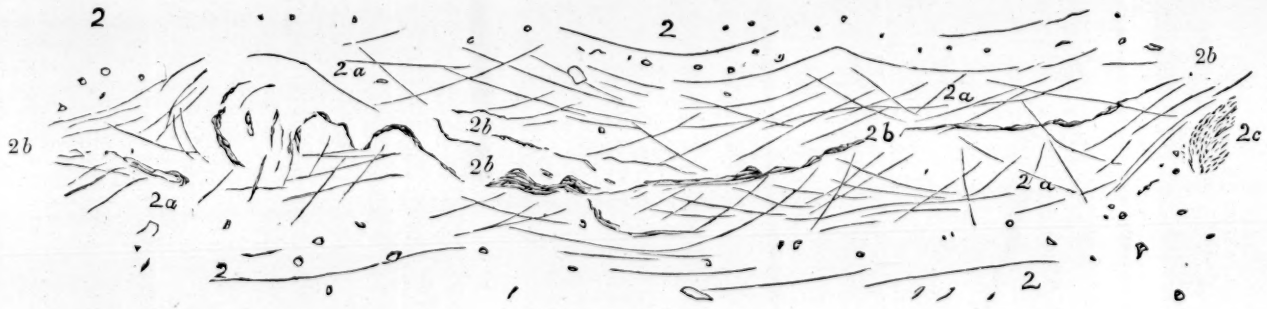
1*b*. Sand and silt, overlying and in places interbedded with 1.

1. Rubble of angular and subangular chalk-blocks and gravel, with an occasional erratic: passes partly into chalky Boulder-clay, 1*a*.

x. White chalk, without flints: surface much shaken.

FIG. 2.—ENLARGED SECTION OF THE SHELLY SAND AND SURROUNDING CLAY AT B. IN FIG. 1.

Scale: 4 feet to 1 inch.



EXPLANATION.

2. "Basement" Boulder-clay.

2*a*. Pure compact blue and brown clay of aqueous origin: bedding contorted and nearly obliterated, but the mass is cut up by shearing-planes.

2*b*. Irregular seam, and scattered streaks, of greenish-yellow sand with many marine shells.

2*c*. Patch of pale yellow sand, different from 2*b*, without trace of fossils.

it places beyond all doubt what has been until recently[1] an undecided point, the extension of the Basement Clay over Flamborough Head, and consequently over a large area in the region to the northward, and this will materially affect the classification of the drifts of that part of the coast.

In conclusion, it may perhaps be as well to mention that the place where the shell-bed is to be seen is on a steep slope at the top of a chalk cliff, and, though not really dangerous, is certainly not easy of access, and is formidable-looking to any one unaccustomed to clamber about on high places.

V.—On the Climate of the Loess Period in Central Europe and the Cause which Produced it.

By T. F. Jamieson, Ellon, Aberdeenshire.

UNDER the name of "*Loess*" there has been confounded two kinds of deposit which are due to entirely distinct and different causes. One is the fine-grained sediment left by the muddy water of flooded rivers and streams of all sorts; the other is the powdery dust and sand carried by wind, which in dry regions often produces large accumulations of this nature.

It would be well, I think, if the term "*Loess*" were restricted to this latter deposit, or at all events it would be desirable to have a distinct geological term for each kind. There is no doubt, however, that both agencies have frequently contributed to the formation of these so-called Loess-beds, for in one and the same locality blown dust and watery sediment may be lodged alternately, according to the varying phases of the weather.

Many years ago Morlot in Switzerland, and Collomb in France, pointed out that much of the material to which the term "*Loess*" is applied in these countries had probably been derived from the muddy streams which flowed from the old glaciers of the Ice-time, for water issuing from the bottom of glaciers is generally loaded with a fine floury sediment produced by the grinding action of the ice upon the mineral matter beneath it. This explanation accordingly met with very general approval; but when the German geologist Richthofen extended his travels into Northern China and Mongolia, he there found Loess-beds developed on a gigantic scale, and displayed in such a way as to announce in no obscure language the cause which produced them. In these arid regions the desert winds play an important part in the economy of nature, and carry along great clouds of sand and dust which they drop in more sheltered places where their force begins to slacken. In moist climates the fine earthy powder which is continually forming on the surface of the country by the action of the weather is washed off by the rain and rivers; but in rainless districts it is left to the mercy of the winds, which in the course of long ages gather deep beds of it, and these so closely resemble in character and in organic contents

[1] See Report on Buried Cliff at Sewerby, British Association for 1888 (p. 335).

the Loess of Central Europe that most German geologists seem now to believe that both have been produced by very similar causes.

A curious and interesting confirmation of this opinion has in recent years been got by Dr. Nehring,[1] of Berlin, who has discovered in the Loess deposits of Brunswick and other parts of Germany numerous remains of animals, such as the *Alactaga jaculus*, *Spermophilus rufescens*, *Arctomys bobac*, and various species of *Arvicola*, which are found only in very dry open districts like the Steppes of Eastern Russia and Siberia. He accordingly maintains that at the time these animals flourished in the heart of Germany, Central Europe must have had a very dry continental climate. In order to account for this dry steppe-like climate, Nehring supposes that Europe had then extended much further into the Atlantic towards the west and north-west, and that there was perhaps even a land communication between it and North America.

My object in this paper is to show that there is no necessity for invoking this great extension of our continent to the westward, and that the dry climate which Nehring wants would arise as a necessary consequence from the train of events which we know took place during the Glacial period. It is now admitted on all hands that when the great Scandinavian Glacier attained its maximum development, it came down like a flood into the plains of Poland and Germany, and advanced onwards until it reached the frontiers of Bohemia.

To the eastward it seems to have stretched over the plains of Russia as far at least as Moscow, if not for some distance beyond it. Such being the case, we need not be surprised to find that it approached the shores of Britain in its westward march, and coalesced with the ice which was streaming out in all directions from Scotland and the North of England. In fact, if the British ice had not been in great force, it is evident the Scandinavian glacier (judging from its range to the south and east) must have invaded this country to a considerable extent, as indeed it seems actually to have done along part of the English coast. We know from the investigations of Messrs. Horne and Peach that its influence was felt at the Orkney and Shetland Islands, while our own Geological Survey, together with Otto Torell and the late Mr. Carvill Lewis, have found traces of its presence from Norfolk to Holderness. Well, what does this imply? The Baltic and the German Ocean must have been for the time abolished, and the western border of the ice would have been thrust out into the Atlantic somewhere probably about the 100-fathom line or beyond it, running along between Shetland and the Faroe Islands, and lying out beyond the Hebrides and the Irish shore. The sea also between Norway and Iceland would probably have been frozen over during most of the year. Here then we have conditions which amply suffice to have produced a dry continental climate in Central Europe; for we have a thousand miles of ice lying between it and the open water of the ocean all round to the north and north-west.

[1] Geol. Mag. Feb. 1883; also, Neues Jahrbuch für Mineralogie, etc., 1889, p. 66.

To the east there was nothing but land, and to the south the great snowy Chain of the Alps shut off in a great measure the influence of the Mediterranean and the Adriatic. Unless it was from the neighbourhood of the Bay of Biscay, it is difficult to see where the rain could come from; and even that is a long way off, with hilly ground between. Now this state of matters would have been more effective than a mere extension of the land such as Dr. Nehring has contemplated, for such a mass of ice lying along the north-western border of Europe would act as a powerful condenser upon the moist winds coming in off the Atlantic. Precipitation would therefore take place before the clouds could reach the heart of Germany, and the climate there would be one of extreme dryness. France would not be so much affected; but in travelling from France eastward through Germany to Austria the dryness would steadily increase. Accordingly it is found that the extent of the ancient glaciers in these regions rapidly diminished as they are traced to the eastward. In the Carpathian Mountains they were small and confined to the higher parts of the chain, as we know from the investigations of Partsch (*Die Gletscher der Vorzeit in den Karpathen*).

The Loess on the other hand seems to augment in volume eastward from the coast of France, as we should expect on the theory I am advocating. It thickens in the Valley of the Rhine, and is largely developed in the basin of the Danube, while over Southern Russia it extends in a continuous mantle.

In England there is a slight suspicion of it in the south-eastern counties. Much of the brick-earth in that quarter probably consists of wind-driven dust mixed at times with sediment proceeding from the muddy water of melting snow and outbursts of rain. There is even some trace of Nehring's Steppe-fauna at Salisbury, where Dr. Blackmore[1] got remains of Lemmings, *Spermophilus*, etc., along with the bones and egg of the Wild Goose.

When geologists attempted to account for these Loess-beds solely by the action of water, they found themselves involved in considerable perplexity, as may be seen in Sir Charles Lyell's chapter on the subject in his "Antiquity of Man," and also in the papers of the late Thomas Belt; for this deposit often occurs on the sides and tops of hills to which flooded streams could hardly be supposed ever to reach. Moreover, the characteristic shells which are everywhere found in the Loess are not aquatic or fluviatile species, but belong to kinds which have a northern range over cold dry regions.

Penck, in his *Landerkunde von Europa*, points out in regard to the Loess that its central point of development lies quite outside the Glacier region, and that it appears in places which were inaccessible both to the ice itself and the melting water proceeding from it. He looks upon it as "*an interglacial steppe formation.*"

If the Loess were a deposit from the muddy water that issued from beneath the old glaciers, how comes it that we do not find it in Scandinavia and Scotland where glaciers abounded? Neither do we hear of it in Eastern Canada or New England. It appears,

[1] Journ. Geol. Soc. vol. xx. p. 192, 1864.

however, in some of the dry regions in the interior of North America, just where we might expect to find it on Richthofen's theory.

I maintain, therefore, that upon meteorological principles a very dry climate in Central Europe was the necessary and inevitable result of the great spread of glacier-ice over Scandinavia and the British Isles, inasmuch as it practically shifted the coast-line from the shores of Prussia and Holland to the westward of Britain and Ireland, at the same time interposing a powerful condenser of atmospheric moisture between Central Europe and the open water of the North Atlantic. If this opinion be correct, it is evidently a mistake to call the Loess "*post-Glacial*." The character of the fauna it contains is indeed decisive upon this point, for, as Mr. Belt[1] insisted, "no more Arctic fauna is known in the basins of the Danube and the Rhine than that of the Loess." It seems likely, however, that as the Scandinavian and British ice grew and gradually occupied the basins of the Baltic, the German Ocean, and the Irish Sea, the precipitation of snow would be more confined to the west, and the glaciers of the north side of the Alps and of Central Europe would diminish for want of supplies. Therefore a considerable shrinking would take place in the latter region during the Loess period, and large tracts formerly covered by the ice would be laid bare; for, owing to the dryness and consequent clearness of the air, the sun in summer would be strong and brilliant, and the snow and ice would melt much faster than it could form again. The Loess would therefore succeed the Glacier in those parts, and would cover the beds of Boulder-clay and Gravel which the ice left behind it, and we might conjecture that in Central Europe the succession of stages would probably be as follows:—

1. A cold moist climate with the formation of peat and lignite beds, indicating the coming on of the ice (*Elephas meridionalis*).
2. The ice in possession of the surface, corresponding to the "Lemming stage" of Dr. Nehring.
3. A cold dry period with a climate like that of South Siberia, and a Steppe-fauna, resulting from the spread of the ice to the N.W. and its shrinkage to the S.E.

VI.—The Paste of Limestones.[2]

By J. G. Goodchild, F.G.S., H.M. Geol. Survey,
Lecturer on Geology and Mineralogy at the Heriot-Watt College.

NOW that so close attention is being given to the microscopic investigation of rock structures, it is somewhat remarkable that no one should yet have questioned the validity of the views currently received regarding the exact constitution of limestone. Taking account only of those limestones whose original structure has not been obliterated by subsequent changes, the general view is

[1] Quart. Journ. Sci. Jan. 1887, "On the Loess of the Rhine and the Danube."
[2] Founded on communications to the Royal Physical and the Geological Societies of Edinburgh.

that nearly the whole mass, in the great majority of cases, is either directly, or indirectly, due to organic agencies. This view is even maintained in the cases where a microscopic examination of the rock fails to reveal more than a few traces of any structure that can be regarded as organic.

It is perfectly true that the exclusively-organic structure of the greater part of many limestones does not admit of any question. No one can doubt that fully 90 per cent. of the matter composing, for example, the shell-limestones of the Jurassic rocks, or the encrinital limestones of the Yoredale Series (which consist of masses of encrinites) must be of organic origin. But there are other limestones, often associated with these, of whose organic origin at all the evidence is by no means clear. Between these two extreme types every intermediate gradation exists. The fact, indeed, may be demonstrated by a careful study of the constitution of the different beds, or posts, of the same limestone, or even of the different laminæ composing the same bed. One such may consist almost entirely of organisms, fragmentary or otherwise; while those associated with it may exhibit hardly a trace of a fossil of any kind. In the case of certain shales associated with limestones, such for example as those of the Yoredale Rocks, the argillaceous bed may be crowded with organisms, while the calcareous bed immediately below may yield but a few traces of such; or else, in some cases, may consist of little else than an amorphous paste of carbonate of lime, in which neither microscopic examination, nor any other kind of investigation, reveals more than a few traces of organic structure.

Those writers who have occupied themselves with the study of limestones seem to have given but little attention to the nature and origin of this amorphous constituent of the rock. Perhaps one reason may be that those who have worked most at limestones have been specially interested in fossils, and have regarded the parts of the rock that did not exhibit traces of organic structure as comparatively devoid of interest. Even Dr. Sorby, in his well-known address on the origin of limestones, passes over this part of the subject with much less notice than one could have wished it should have received from him. He refers it chiefly to the crumbling down of the aragonite of calcareous organisms that were undergoing decomposition;[1] but part of it he refers to the detrition of older limestones, and part of it he regards as a chemical precipitate. Professor Prestwich (Geology, vol. ii. p. 320) suggests that the impalpable amorphous matter that forms so large a part of the Chalk, for example, "may really be a chemical precipitate thrown down under special and peculiar conditions prevailing at the time." Amongst other explanations is that based upon the fact that the seaward face of coral reefs is always undergoing considerable wear and tear under the action of breakers, and that much of the fine chalky matter resulting from this action is distributed far and wide

[1] On this subject see Vaughan Cornish and Percy F. Kendall, "On the Mineralogical Constitution of Calcareous Organisms," Geol. Mag. Dec. III. Vol. V. p. 66.

over the ocean-floor, where it subsides as a thin stratum of impalpable calcareous mud. Since the time that coral animals assumed the reef-building habit (which many think was not earlier than Mid-Tertiary times) such a factor must have been an important one in the production of the paste in question. Even in Pre-Tertiary times, before there were any coral reefs, the wear and tear of other calcareous organisms must have contributed to the same result. But as such action, from the nature of the case, must have been confined to littoral regions, it can hardly be taken much into account in dealing with the present question. It is quite clear in the case of the older limestone that the paste did not result from the detrition, on the spot, of the calcareous exuviæ existing on the sea-bottom; for, be the calcareous organisms what they may, they retain their original sculpturing, or other ornamentation, in as perfect a condition, so far as wear is concerned, as it was during the lifetime of the animals. In the course of several years' close study of everything relating to limestones, in the field and in the study, I have never yet come across a single instance where any evidence whatever of such attrition could be made out.

Another explanation sometimes given is that, when calcareous organisms have lain for any length of time on the sea-floor, they are attacked by chemical agencies, and are thereby dissolved more or less—the solution being, under different conditions, redeposited as a chemical precipitate. Without questioning the validity of this theory in particular cases, it will suffice to remind the reader that many of the facts tell strongly against such a view. When animals build up a calcareous framework, the carbonate of lime is invariably mixed with more or less organic matter, allied to chitin in many of its properties. The function of this substance, as Bischoff long since pointed out, is to enable the hard parts of the animals to resist the attacks of agents tending to bring about any such corrosion. As a matter of fact it is usually not until long after the animal has been dead, and its shell has been exposed to the attacks of subaërial erosion, that it begins to go to pieces at all. As a consequence, it is as rare to find a corroded shell, for example, in any limestone clearly of marine origin, as it is to find amongst recent shells the apex of an aged Gasteropod, or the umbo of a full-grown Lamellibranch, showing any sign of corrosion. It is only where the forces connected with subaërial denudation come into play that any such corrosion appears to be possible.

Another factor that may contribute to form some of the paste of limestone is the agency of certain fishes and molluscs that feed upon organisms secreting calcareous frameworks. Part, at least, of the finely-comminuted stony matter swallowed by these predatory animals is subsequently voided, and eventually subsides to the bottom. From the very nature of the case this can hardly ever have been of much importance in the present connection, although it cannot well be left altogether out of account.

Other explanations also have been from time to time advanced; but not one of them has proved altogether satisfactory.

The one explanation that would have satisfied all the requirements of the field geologist is, that the greater part, or the whole, of the paste in question is mainly due to chemical precipitation. But until quite lately chemists assured us that the facts then known did not warrant the assumption that any precipitation whatever of carbonate of lime was possible in the open sea. This view was mainly based upon the fact that all analyses of sea-water showed that the percentage of carbonate of lime held in solution was but a small fraction (a tenth, or thereabouts) of what sea-water was capable of dissolving. Therefore, it was pointed out, precipitation of carbonate of lime was simply impossible. That is no doubt perfectly true so far as it goes. But were the reactions that had been considered the only ones possible? More recent researches have shown that they are not. To these I shall refer in more detail presently. In this connection one very curious fact must surely have struck others engaged in teaching geology, as it struck me. In dealing with the enormous quantities of carbonate of lime that the rivers of the world are carrying seawards, one is called upon to explain how it happens that, off the mouths of those rivers, an analysis of the sea-water fails to show more than a trace of either carbonic acid or carbonate of lime. On the contrary, the composition of the sea-water there is practically identical with that of the ocean far from land. What has become of the carbonate of lime? We are told that it has been assimilated by organisms. That seems a reasonable explanation at first sight. But where *are* the organisms that effect this remarkable change so rapidly? Surely no one is prepared to maintain that the animals and the plants that build up organic carbonate of lime come to the mouths of rivers specially to obtain the supplies necessary for their purpose? The facts tell quite the other way. Indeed, the proportion of such organisms living just where river-water and sea-water mingle, to those living out at sea, is almost infinitely small. In other words, where carbonate of lime in solution is in excess, the percentage of organisms with calcareous frameworks is probably not as high as it is where the carbonate of lime is known to be deficient. If for that reason alone, it is quite clear that such an explanation is at fault.

If the carbonate of lime has not been extracted by organic agencies, then it must have disappeared through some reaction between the solutions of carbonate of lime in carbonated fresh water on the one hand and the saline constituents of sea water on the other. In other words, the carbonate of lime has passed into some other compound. What the exact nature of that compound is must be left to chemists to decide. But it is stated by Dr. Sterry Hunt, that if a solution of carbonate of lime in carbonated water be mixed with a solution of sulphate of magnesia in water, double decomposition ensues, and carbonate of magnesia and *sulphate of lime* are formed. Magnesian sulphate exists in sea-water in proportions, per 1000 parts of water by weight, varying from 2·20 to 6·40. If this is really in accordance with the results of modern researches, then we seem here to obtain a clue as to what is happening. The

carbonate of lime brought seawards by rivers does not reach the sea as *carbonate*, but is poured unceasingly into the ocean as *sulphate of lime*. Hence the sudden disappearance of carbonate of lime at the point where river waters and the water of the sea meet.

That being the case, what becomes of all the sulphate? Sulphate of lime *is* present in all sea-water in proportions per 1000 parts by weight varying from 1·35 to nearly 4. But unless some agency is at work extracting this lime-compound from sea-water as fast as it is brought in, it is obvious that sulphate of lime would go on accumulating until the saturation point were reached, when precipitation would ensue. But, as all the researches that have yet been made have failed to bring to light the smallest proof of the existence of such precipitates in the open sea, it was an obvious conclusion that, in some way or other, the sulphate of lime was extracted by organic agencies, and that it was from this source, and not from carbonate of lime, that corals, molluscs, fishes,—in short, all marine organisms whose hard parts consisted of carbonate of lime,—obtained the supplies necessary for their purpose. And this was the view to which I had been independently led, and which was set forth in one of the papers referred to at the head of this article, without knowing that the fact had been actually demonstrated already.

The researches that led to the demonstration referred to were conducted near Edinburgh by Messrs. R. Irvine, F.C.S., and G. S. Woodhead, M.D., in 1888 and 1889. The results were made known in two papers read before the Royal Society of Edinburgh, the first in May, 1888, and the concluding part in May, 1889. They are published in the Proceedings of that body for 1888–9, part xvi. Their chief conclusions are of great importance to both biologists and geologists. The authors supplied various animals with different lime-compounds, singly, or in combination with other salts; and they proved by the results that organic beings possessed the power of decomposing all lime compounds during digestion, sulphate of lime amongst others; and that, through organic agencies, the resulting lime, entering into fresh combination with carbonic acid, and temporarily, also with phosphoric acid, is ultimately deposited and is left, while the phosphoric acid is apparently reabsorbed and is utilized afresh (*op. cit.* p. 340). In this way they consider "carbonate of lime may be secreted by marine animals, which have the sulphate of lime presented to them in the presence of chloride of sodium" (*ibid*, p. 350). And, lastly, they observe, "the carbonate of ammonia produced by the decomposition of urea, etc., decompos[es] a portion of the sulphate of lime of sea-water, with the formation of carbonate of lime equivalent in amount to the carbonate of ammonia thus formed" (*ibid*, p. 336). The papers referred to contain a valuable body of facts and observations relating to the formation of carbonate of lime by organic agencies other than those with which this paper is more directly concerned. But apart from these, the authors have unquestionably cleared away the principal mystery that has hitherto surrounded the origin of the organic constituents of limestones.

To return to the origin of the paste, with which Messrs. Irvine

and Woodhead have not dealt:—It is a well-known fact that solutions of sulphate of lime in the presence of decomposing organic matter tend first to be reduced to the sulphide, and ultimately to be thrown down as a precipitate of carbonate of lime. In a paper on "Some Modes of Formation of Coal," read before the Royal Physical Society of Edinburgh, on April 17th, 1889 (published in the "Colliery Guardian," May, and, in a different form, in the GEOL. MAG. July, 1889), reference was made to this factor in connexion with limestones of inorganic origin. Such limestones would necessarily consist almost entirely of an amorphous calcareous paste in which animal organisms might or might not occur, although bituminous matter due to the partial or the complete decomposition of vegetable organisms might be present in variable quantity. In the field, limestones of this nature are of common occurrence in connection with beds of coal, as might be expected on the view of the origin of both these rocks advocated in the papers referred to. From such inorganic limestones a passage can readily be traced in one direction through clay ironstone, and blackband ironstone, into coal; while in the other direction (presumably that farthest from the land) such limestones gradually pass, by the addition of imbedded calcareous organisms, into limestones of the normal type. This led me, by inference drawn from another set of facts, to the conclusion that chemical precipitates, due to the reaction of decomposing organic matter upon sulphate of lime, have an essential influence upon the formation of limestones, even when these are mainly of organic origin. Wherever organisms are living, at that place also are other beings that are passing into the inorganic condition. In the case of those of marine habitat, it has been shown that these secrete carbonate of lime out of the sulphate of lime of sea-water while they are living; and the products of decomposition bring about a precipitate carbonate of lime from the same source when they are dead. Such action is not by any means necessarily limited to the tenants of the sea-floor, for the decomposition of pelagic organisms is likely to contribute more or less to the same result. Nor is it limited to organisms with calcareous frameworks, but may result just as much from the decay of, say, jelly-fishes, or sponges, as from their lime-secreting allies.

It is to this organico-chemical agency that I would refer the origin of the greater part of the paste of limestone of marine origin.

The shell-marl of lakes presents limestone paste under a somewhat different form. Even in this case the bulk of the rock is derived partly from the precipitation, by decomposing organic matter, of the carbonate of lime from the sulphate carried in solution into the lakes; partly from the precipitation of the carbonate of lime directly from solution by the withdrawal of part of the solvent carbonic acid by the agency of subaqueous vegetation; partly also by the actual decomposition of the shelly matter itself, under the corroding influences of the acidulated waters. Shells themselves, as a rule, of course, form but a small part of shell-marl.

If the views here advocated find acceptance amongst geologists, it

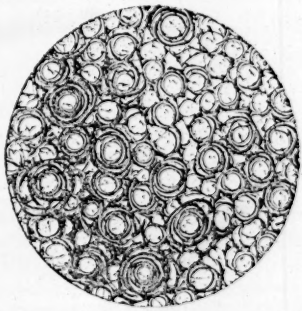
is clear that we shall have to regard all limestones as of compound origin, partly organic, partly detrital, partly as chemical precipitates —the proportion of each to the other varying greatly to a much greater extent than has yet been recognized.

VII.—On a Method of Producing Perlitic and Pumiceous Structures in Canada Balsam.

By Frederick Chapman.

THE interesting phenomenon exhibited in some glassy rocks, such as obsidians and pitchstones, known as the perlitic structure, consists of a series of rectilinear and curved cracks. It has been produced artificially in Canada Balsam, and described by Mr. Grenville A. J. Cole, F.G.S.[1]

Hitherto, any attempts of mine to produce the curved or secondary cracks on a glass plate were unsuccessful (the only result being primary cracks and appearances of air films between the glass and balsam); until noticing their occurrence on a rough mounting plate, it became evident that a *roughened* glass surface was the requisite thing in order to secure perfect cohesion. It is probable, therefore, that the specimen which Mr. Cole produced occurred on a ground portion of the glass plate.



For a cabinet specimen one cannot do better than to take a disc of glass of about 1¼ inches in diameter; or if it is wanted for microscopic examination it may be necessary to use a 3 × 1 slip. One surface of the glass is then ground on emery powder; meanwhile Canada Balsam is prepared in an evaporating basin by heating to brittleness. The balsam is taken whilst beginning to cool and poured on the glass, which has been slightly warmed to allow the balsam to flow without including bubbles. When the balsam has cooled slowly to a firm condition, but not quite cold, the plate is plunged into a vessel of cold water. Immediately this is done the rectilinear and subsequently the curved cracks appear throughout the entire layer of balsam. With a little care, very perfect and beautiful examples of the perlitic structure may be prepared in this way.

[1] On the Artificial Production of Perlitic Structure, Geol. Mag. Dec. II. Vol. VII. 1880, p. 115.

By various experiments it appears that the coarseness of the structure depends on, first, the thickness of the balsam heaped on the plate (when thinly spread the tendency is for the structure to be fine); second, the coarseness of the emery used in roughing the surface of the glass (fine flour emery generally giving rise to almost microscopic structure).

The illustration given is from a photograph of an actual specimen. The pumiceous structure, with its characteristic silky lustre, may be obtained by taking Canada Balsam made brittle by evaporation, and whilst in a soft condition stirred and beaten up with a thin strip of metal previously made warm to prevent the cooling of the balsam, until the soft mass is thoroughly permeated with air bubbles. It is then taken in a lump and pulled out several times, when the lustrous substance is obtained. This product resembles very closely the Schiller Obsidian of the Caucasus.

The above experiments were for the most part worked out in the Geological Laboratory of the Normal School of Science.

REVIEWS.

I.—A Manual of Palæontology for the Use of Students, with a General Introduction on the Principles of Palæontology. By Henry Alleyne Nicholson, M.D., D.Sc., F.G.S., etc., Regius Professor of Natural History in the University of Aberdeen, and Richard Lydekker, B.A., F.G.S., etc. Third Edition. Re-written and greatly enlarged. In Two Vols. Royal 8vo. pp. 1624, with 1419 Woodcut Illustrations. (William Blackwood & Sons, Edinburgh and London, 1889.)

THE contents of these two portly volumes fully bear out the authors' statement in the preface as to the rapid advance of palæontological science within the last ten years. When compared with the second edition issued in 1879, we find, notwithstanding the employment of somewhat smaller type and leads, an increase of 554 printed pages, whilst the number of the illustrations is nearly doubled. So great have been the changes and discoveries in the science within the last decade, that it has been found necessary to entirely rewrite and recast the whole; hence it has a just claim to be considered as a new work. The great development in the history of fossil Vertebrates within the last few years has also made it almost impossible for any one not a specialist to treat this branch of the science in a competent manner, and it is therefore a decided advantage to find that in this edition the description of the Vertebrates has been undertaken by Mr. R. Lydekker.

Not only, however, do these volumes indicate a decided increase in our knowledge of fossil organisms in recent years, but they also furnish satisfactory evidence of the improvement which has taken place in the character and methods of palæontological research, so that, whatever may have been its deficiencies in the past, palæontology has now a just right to recognition as a separate department of

Biology. It is still the fashion with some zoologists of the present day, whose studies are limited to recent organisms exclusively, to regard with lofty scorn the pretensions of palæontologists to be scientific in their aims and methods; but such pharisaic contempt is certainly undeserved by the present workers in this science, who are not content now, as in former times, with a mere description of the outer forms of fossils, but by means of sections and the microscope endeavour to ascertain all that can be known of the structure and relations of the organisms they study.

Taking into account the changes produced in fossilization, and the generally fragmentary condition of fossils, the task of the palæontologist in investigating extinct forms is far more difficult than that of the student of recent species, who has perfect materials at his disposal. As a rule, those who are purely zoologists seldom care to meddle with fossils, or, if they do, they frequently give abundant proof that something more than a knowledge of recent organizations is needed to interpret rightly the remains of extinct forms. It is fairly certain, that but for the work of those who have given their entire attention to fossil forms, but little comparatively would now be known of the life of the past, for the zoologist finds abundant recent material waiting for his study, and as this is more attractive and less difficult than the fossil, there is no temptation for him to forsake the recent for the study of past life.

Returning now to the Manual, we may note as one of the best features in this edition, the consideration given to the minute structure of the different groups of organisms. This, however, is limited to the Invertebrates; for though the microscopic structure of certain of the hard structures of fossil Vertebrates is of considerable importance in determining their affinities, there are no figures given of this in the second volume. It is of the greatest advantage to the student to be able to recognize in sections the nature of the organic fragments of which many rocks are largely composed, and it is sometimes as important to determine whether a rock consists of crustacean, echinodermal, or molluscan remains, as to know the particular genera or species which may be present in it. In this edition we are glad to see good figures of the minute structures of Foraminifera, Corals, Stromatoporoids, Echinoderms, Annelid tubes, Trilobites, etc. Aided by these the student is not likely to refer the plates and teeth of fishes to Stromatoporoids and fossil Sponges—a mistake which has been made in pre-microscopic days.

In spite of the greatly increased contents of these volumes, it is well to bear in mind the authors' statements that only the leading types of each great group of fossils have been selected for notice and characterization. To the student indeed the number of these leading forms might seem sufficient to embrace all that have been discovered; but the specialist, who knows something of the extent of his own particular department, is conscious of the great amount of condensation which has been necessary to keep the work within its present limits, and he possibly might find, here and there, reason to regret the brevity with which some subjects have been

treated. There is no doubt, however, that the work furnishes the student with an excellent summary of the leading principles and facts of palæontological science—by far the most complete which has ever been published in the English language—and any one who wishes to gain either a general knowledge of the past life of the earth, or a guiding key to any particular division, cannot do better than make use of its assistance.

The first volume, for which Professor Nicholson is specially responsible, contains the General Introduction and the Invertebrata. It comprises 44 chapters, of which seven are devoted to the Introduction. The first part of this relates to the character and mode of formation of the sedimentary rocks, and the conditions under which fossils occur in them. Good figures are given of the microscopic structure of different varieties of fossiliferous limestones, including the White Chalk, which is compared with a section of the Globigerina mud from the depths of the Atlantic. Reference is also made to the organic siliceous rocks, such as flint and chert, which, as we now know, owe their origin to Sponges principally. Following a table of the chronological succession of aqueous rocks, full explanations are given of the migration of species, contemporaneity and homotaxis, the value to be attached to marine, as compared with land and fresh-water fossils; geological continuity, life-zones, and the now obsolete doctrine of intercalated colonies. In the succeeding chapter the causes of the imperfections of the Palæontological Record are pointed out, and some remarks made on the theory propounded by Murray and Rénard that there are no geological representatives of abyssal deposits. It is evident, however, that certain portions of the sedimentary series fully correspond with the Foraminiferal ooze, the Radiolarian ooze, the Diatom ooze, and even with the Pteropod ooze, and it is by no means improbable that some of the variegated, fine-grained muds of the Cambrian and Ordovician strata may correspond to the abyssal clays of the present oceans. The question of the climatic conditions of the earth in former geological periods is also one on which no certain conclusions can be drawn from fossils—at all events on those from the older rocks; but the researches of Neumayr on the animal life of the Jurassic period indicate the existence at that epoch of climatic zones similar to those of the present day, and there is also a certain amount of evidence of the recurrence of Glacial periods at different epochs in the past.

As regards the terms used in palæontology, the author remarks that they are the same as those employed by the zoologist; but owing to the fact that as almost without exception the specific characters of fossils must necessarily be founded on the hard structures only, and these often imperfectly preserved, it follows that a palæontological species cannot be expected to have the same value as that which a zoological species ought to have when the entire structure of the organism can be taken into account, and consequently both the species and the genus must be accepted in a wider and less strict sense in palæontology than in zoology. The author adopts the

definition of a palæontological species given by von Zittel, viz. that it comprises all those individuals, or remains of individuals, which possess in common an assemblage of constant characters, and which constitute collectively a distinctly circumscribed morphological series, apart from all considerations relating to their range in time and in space.

The final chapter of the Introductory part treats of the Evolution of Organic Types in time. The author points out that we are quite ignorant of the animals and plants which constituted the first living beings, and that we are likely to remain so; that representatives of all the invertebrate sub-kingdoms are present in the earliest fossiliferous deposits, and these as individuals are complex and highly specialized in their structures, and we are bound to conclude that these earliest known faunas must have been preceded by many others altogether unknown to us, in which the gradual changes from the primitive simpler types of life took place. Throughout the entire geological succession we can note a continuous introduction of new species, sometimes gradually, at others apparently very abruptly, but the evidence of palæontology points to the operation of some general law of evolution, by which these new species have been derived from pre-existing forms. This succession of life-forms is further progressive in character, the evidence of palæontology indicating a distinct advance in complexity of organization of the later as compared with the earlier morphological types. There is but little chance of ascertaining from the rocks any knowledge of the order of the appearance of the different leading types of Invertebrates; but we ought to be able to find traces of the first appearance of the higher classes of Vertebrates. The author remarks that there is no *direct* palæontological evidence which would certainly establish any particular theory as to the precise mode in which this law of evolution has been carried on, nor is the evidence from this source conclusive as to the theory of the origin of species by natural selection. Whilst it is true that in a certain number of instances it has been found possible to connect two different specific types by means of a long series of intermediate links, as a general rule, the known transitional forms between allied groups are few in number. "It cannot be doubted, therefore, that palæontology has, so far, to a large extent, failed to bring forward the numerous and *closely graduated* series of intermediate forms which must at one time have existed, supposing 'natural selection' to be the sole agent in the origination of new species. The absence of a sufficient number of such transitional forms, and the insufficient connection between such as are known to exist, may doubtless be in part explained by the known 'imperfection of the geological record'; but this does not appear to offer an adequate solution of the difficulty. The theory of the 'origin of species by means of natural selection,' as elaborated by the master-mind of Darwin, constitutes nevertheless an invaluable, indeed, an indispensable guide in all branches of palæontological research."

The greater part of the first volume treats of the palæontology of

the Invertebrata. We can within the limits of this notice only refer to some of the changes and additions which appear in this new edition. In Foraminifera, for instance, there is introduced the new arrangement into families proposed by Dr. H. B. Brady, in the "Challenger" Report, in which the structure of the test as an exclusive basis of classification has been abandoned. Figures are given of some of the peculiar forms of the recent Astrorhizidæ, in which the test consists of arenaceous tubes, and to these the peculiar genus *Girvanella*, lately shown to occur in many limestones from the Cambrian to the Jurassic, is thought to be allied. The group of the Dactyloporidæ, formerly included with the Foraminifera, now finds its place with the Algæ. In an Appendix, several pages are devoted to a consideration of the structure of *Eozoon*, which the author has investigated for himself, and some excellent woodcuts, drawn from the author's own sections, convey a very good idea of the microscopic appearance of this peculiar substance. Professor Nicholson by no means rejects as inadmissible the idea of its organic origin, but thinks that "until mineralogists or petrologists are able to point, in some unquestionable mineral or rock, to a structure strictly comparable with the 'canal system' of *Eozoon*, they are not entitled to assert positively that the latter has a purely inorganic origin." But a similar argument is applicable to those who assert its organic origin, although no organism is known with a canal system strictly comparable to this alleged structure in this rock. It is to be hoped that the active investigation now in progress as to the origin of the rocks in which *Eozoon* occurs, may help to decisively solve the problem as to its real character.

In the chapter on Radiolaria, an outline is given of Haeckel's new classification, and mention made of the presence of these organisms in Jurassic strata where they form beds of jaspery chert. As the microscopic structure of the siliceous organic rocks is better known, this group will most likely appear more important as a rock-former than has hitherto been supposed.

The Sponges, which in the last edition were included under Protozoa, are now placed in a separate sub-kingdom—the Porifera—intermediate between Protozoa and Cœlenterata. They are divided into two classes: the Plethospongiæ, embracing the siliceous and horny forms, as well as those without any hard skeleton, and the Calcispongiæ. Our knowledge of the organization and distribution of the fossil Sponges has greatly extended within the last decade; but owing to the liability of their skeletons to break up, we are still ignorant of the complete forms of many of the older types, and these can at present only be determined by their scattered spicules, which are numerous enough to form considerable thicknesses of rock, more particularly in the Carboniferous epoch. The family of the Receptaculitidæ is, on Hinde's determination, included with the siliceous sponges; but Dr. Rauff, as mentioned in the Appendix, questions the correctness of this reference, though he is unable to refer this puzzling group to any other division of the Animal Kingdom.

Fossil Calcisponges are now known to have a wide distribution and to be abundant in Jurassic strata; their very existence as fossils was denied up to a very recent period; on the other hand, forms formerly referred here, such as the Stromatoporoids, are now placed in the Cœlenterata.

The Archæocyathinæ, from the Cambrian strata of Europe and America, are regarded as of doubtful affinities; but recent researches show that they possess a considerable resemblance to Madreporarian Corals. The real nature of *Pasceolus*, *Cyclocrinus*, and *Nidulites* is still uncertain.

Coming now to the Hydrozoa, there are good figures of *Hydractinia* and *Parkeria*, and also of the peculiar genera *Mitcheldeania* and *Solenopora*, which form an important part of many Palæozoic limestones. *Oldhamia* is still retained with the Hydroida, though its nature is open to great doubt.

Passing over the Graptolites, of which several new figures are given, we reach the Hydrocorallines and Stromatoporoids, and, as might be expected from the author's researches in this latter group, their structural features are clearly described and illustrated. They are considered as forming a special and now unrepresented group of Hydrozoa, some forms having relations to the recent Hydractinia, and others to Hydrocorallines like *Millepora*.

Considering the importance as fossils of the Actinozoa or Corals, we are glad to note the greatly increased space devoted to them in this edition, so that their general features, different modes of growth and increase, and more particularly their minute structural characters, are treated fully, and well shown in the elaborate figures, most of which are original. It is acknowledged that the classification of this group is in a transitional state, and that the position of the Rugosa as a separate order cannot be maintained; but it is still kept distinct, and with the Aporosa, Fungida and Perforata, form the primary sections of the Madreporaria. There can be little doubt however, that many, if not most of the Rugosa will enter into the division of the Aporosa. One of the principal grounds of distinction was based on the supposed tetrameral development of the septa, but the importance of this has been overestimated, and we find here that the Coral, *Stauria astræiformis*, in which this tetrameral arrangement is most conspicuously shown, has been removed from the Rugosa and placed with the Astræida in the Aporosa.

To the section of the Madreporaria Perforata, previously regarded as almost exclusively Mesozoic and Tertiary, considerable additions have been lately made from the older rocks. Thus we have the genus *Calostylis* from the Wenlock, *Cleistopora* from the Devonian and *Palæacis* from the Carboniferous; whilst the great family of the Favositidæ, formerly in the now obsolete group of the Tabulata, also finds its place in this division. Though somewhat more aberrant in their mode of growth, the Syringoporidæ and the Thecidæ are likewise included in the Perforata.

The Palæozoic families of the Heliolitidæ and the Halysitidæ are placed with Alcyonarian Corals on account of their presumed

relationship to the recent *Heliopora*. It is, however, pointed out that their minute structures are widely different, and that the autopores or corallites generally possess a constant number of septa. Other differences might also be mentioned, and there is room for doubting whether the interstitial tubes in these old fossils were tenanted by rudimentary polypes as is stated to be the case in *Heliopora*; for in the genus *Plasmopora* the intermediate tissue is vesicular instead of tubular in character. In many respects the Corals of these families show a relationship to *Syringopora*.

Considerable advance in our knowledge of the microscopic structure of fossil Corals has been lately made, and it seems likely that in any fresh classification the minute structure of the walls and septa will have to be taken into account as an important feature in the relationship of different forms. The significance of this is well shown in the figures given on page 247 of transverse sections of a recent *Caryophyllia*, and of two Palæozoic Corals, *Streptelasma* and *Zaphrentis*, in which the structure and arrangement of the septa are essentially similar in all, though in the present accepted classification the former genus is widely separated from the latter.

Some important remarks are contributed on the nature of coral reefs, and the difficulty is pointed out of determining whether the outcrops of coral limestones in the older rocks really represent the boundaries of coral reefs comparable to those now in process of formation.

A group of organisms, the Monticuliporoids, very numerously represented in Palæozoic rocks, and about whose affinities much uncertainty rests, are treated in a separate chapter. These forms have been more especially studied by the author, who regards them as probably Corals, but other authorities consider them to be Polyzoa. Waagen has lately stated that the mode of increase in some of these forms is by cœnenchymal gemmation, like that of some undoubted Corals, but there is reason to doubt the accuracy of this observation, and it is likely that the mode of growth, in some of the Fistuliporidæ at least, is similar to that in Polyzoa.

The sub-kingdom of the Echinodermata is considered in the Chapters xxii. to xxvi. Good figures are given of the minute structure of the skeleton, so characteristic of the whole group, and reference made to the distinctive cleavage which reveals at once the presence of these organisms in the rocks. The group is ranged under two divisions: the Echinozoa, which includes the Echinoids, Asteroids Ophiuroids and Holothuroids; and the Pelmatozoa embracing the Crinoids, Cystideans and Blastoids. Important additions are made in all these divisions in the present edition, more particularly in the Crinoids and Blastoids. The former class is divided into Neocrinoids and Palæocrinoids; but owing to recent discoveries in the structure of *Encrinus* and *Taxocrinus*, this arrangement will have to be abandoned, and the classification of Wachsmuth and Springer, modified by Dr. P. H. Carpenter, will take its place. In this, the Crinoids are divided into three orders: the Coadunata, Inadunata, and the Articulata. In the Blastoids, the divisions into the two

primary orders of Regulares and Irregulares, proposed by Etheridge and Carpenter, are adopted. The long extinct Cystideans present considerable difficulties in their arrangement. In the Appendix, Dr. Carpenter contributes a note on certain structural points of some of the Bohemian forms described in Barrande's posthumous work on this group.

In the chapter on fossil Annelids, the microscopic structure of some of the Tubicolæ is figured, as well as that of the peculiar *Cornulites* from the Wenlock. Some of the minute chitinous jaws of the Ordovician Polychetæ are also shown.

Barrande's classification of the Trilobites is adhered to, but it seems that even in this group no strict zoological arrangement is as yet possible; it is regarded as more nearly related to the Merostomata than to any other division of the Crustacea. Figures are given of the minute structure of the test, and also of the appendages discovered by Walcott on the under-surface of the body of *Asaphus*.

Under the Arachnida, interesting figures are given of the structure of the chitinous skin of a fossil Scorpion from the Carboniferous rocks of Scotland, and of a recent specimen of this group.

Several new figures of the minute structure of the Polyzoa and of the beautifully-marked cells of the Cheilostomata are added in this edition. The peculiar form of the cell-apertures in *Coscinium cribriforme* (p. 610), and in *Cystodictya Gilberti* (p. 631) is very suspiciously like those of the Monticuliporoid *Fistulipora trifoliata* (p. 358), and might lead one to suppose a near relationship between these forms.

Owing to the comprehensive labours of the late Dr. Davidson, there are fewer changes in the Brachiopoda than in other groups. The principal novelties are the forms from the Carboniferous strata of India, described by Waagen under the names of *Oldhamina* and *Lyttonia*.

In the Lamellibranchiata, Fischer's new classification is adopted in preference to the former one based on the presence or absence of siphons. As becomes the importance of this group, most of the representative types are figured.

The old divisions of the Gasteropoda into the Pulmonata and Branchiata are maintained, but the Chitons and Dentaliidæ are regarded as forming two separate classes of Mollusca. In the Pteropoda, the delicate calcareous tubes known as *Styliola fissurella* are believed to be genuine representatives of the group. Some of the Devonian Limestones in North America are almost exclusively composed of these small tubes; the section figured shows this remarkably well. *Tentaculites* is still retained in the Pteropoda, but the structure of its shell throws considerable doubt on its relationship to this group.

The concluding four chapters of this volume treat of the Cephalopoda. Many additional figures illustrate their structure and early stages of growth. In the Nautiloidea the family divisions lately proposed by Foord are adopted, and the Ammonites are arranged according to the classification of von Zittel.

(*To be continued.*)

II.—Proceedings of the Cotteswold Naturalists' Field Club for 1888–1889, Vol. IX. Part 4.

THE Cotteswold Club continues its good work, notwithstanding the heavy losses it has sustained of late years, by the death of Wright, Guise, Witchell, Lees, and Symonds. Excursions have been made to Cheddar, Edgeworth, Crickley and Tetbury, but though old hunting-places are revisited, yet, as Mr. W. C. Lucy (the President) remarks, "there is ample ground for more detailed work, which can only be accomplished in a satisfactory manner by those who live, like our members, in the area." Moreover, "The subject has become so vast as to make it necessary to divide its study into many parts; and hence, instead of the naturalist of broad general knowledge, there will inevitably spring up specialists who will work in various departments, and the mere 'all-round man' will soon be a fossil of the past."

The number of original workers in any society or field-club is but small compared with those generally interested in the pursuit of science and who are content to follow in the footsteps of others. To this larger body of enthusiastic students geology is mainly indebted for its support. We have been told that among those who contribute most largely to the "talus-heap of geological literature," there are some who affect almost to disregard the writings of others; but they are apt thereby to burden the 'talus' with needless contributions, like the individual in "Punch" who never read books; he *wrote* them. If the original worker finds the productions of others very dry, what must be the feelings of the ordinary student! Probably, as a rule, insufficient attention is given by those who write papers to the wants and capacities of the would-be reader. If the work of the specialist is intended only for specialists, the results can be known to but few, and the enthusiasm of the general student will be damped by his inability to keep up with the progress of the science. We feel this in glancing over the list of fossils in Mr. S. S. Buckman's paper on "The relations of Dundry with the Dorset-Somerset and Cotteswold areas during part of the Jurassic period." The familiar *Rhynchonella spinosa* appears under the name of *Acanthothyris spinosa*, and other well-known forms are obscured by the new generic titles of *Glossothyris*, *Dictyothyris*, *Zeilleria*, *Aulacothyris* and *Plesiothyris*. Surely science is hindered by the prominent use of these subgeneric names, which are of biological but not geological interest, and are only of service as working-material to the specialist. Again, in a list of Ammonites, 22 species are recorded under 11 subgeneric names, some of which moreover have undergone repeated changes. As these names can convey a clear meaning to few besides specialists, we regret that they were not placed in brackets after the ordinary generic name.

We have dwelt on this subject, as the nomenclature adopted by Mr. Buckman renders it difficult to follow his arguments. He endeavours to show that the Inferior Oolite, of which Dundry is mainly composed, was in its lower portion connected intimately with the Dorset and South Somerset area, while only the upper portion

or *Parkinsoni*-zone was connected also with the Cotteswold area. He believes that a barrier was raised "*after* the deposition of the Lower Lias and just before that of the Cotteswold Sands," and that this barrier, for a time, disconnected the Bath and Cotteswold area of deposit from that of Dundry and the Dorset area. From the evidence brought forward this may be taken as an interesting and important suggestion made to explain certain palæontological differences between the strata in the respective areas.

Mr. Lucy contributes "Remarks on the Dapple Bed of the Inferior Oolite at the Horsepools, and on some Pebbles from the Great Oolite at Minchinhampton." The Dapple bed is the quarrymen's name for a layer of Oolite that contains tiny quartz pebbles, and also pebbles of Oolite distinguished from the matrix by a difference in colour and texture. These latter, as Mr. Lucy remarks, evidence "the destruction of older rocks of the same nature during, or previous to, the deposition of the existing Oolite;" while the quartz pebbles he considers to have been derived from the Forest of Dean. The pebbles said to have been obtained from the Great Oolite had, in Mr. Lucy's opinion, been derived from the Drift, but had dropped down a fissure in the Oolite.

The Rev. H. H. Winwood furnishes "Notes on a Geological Section between Tytherington and Thornbury." A very neatly-drawn coloured section accompanies the paper; and it may be mentioned that this differs in some minor particulars from the section published by Prof. Lloyd Morgan (Proc. Bristol Nat. Soc. vol. vi. part i.). The section depicts the cuttings on a new line of railway, and shows the Old Red Sandstone passing upwards through the Lower Limestone Shales into the Carboniferous Limestone. Full details of the strata are given by Mr. Winwood. At one point a reversed fault brings fine-grained beds of Dolomitic Conglomerate (like Magnesian Limestone), beneath the Carboniferous Limestone. Other sections show Dolomitic Conglomerate, Keuper Marl and Sandstone; and altogether the making of the railway has furnished a very instructive series of cuttings. H.B.W.

III.—Structures et Classification des Roches Éruptives. *Par* A. Michel Lévy. pp. 95. (Paris, 1889.)

THIS is primarily a spirited attack on the principles laid down by Rosenbusch in his *Mikroskopische Physiographie der massigen Gesteine*, and a revindication of those already set forth by the author in conjunction with Fouqué. Though perhaps stronger on the critical than on the constructive side, this little volume is full of fertile suggestions, and is certainly the clearest exposition of the views of the French school which has yet appeared.

The author maintains that the plutonic (*granitoïde*) rocks, no less than the volcanic and porphyritic (*trachytoïde*), present evidence of two distinct periods of crystallization, the products of which may be easily discriminated; but that in the former class the minerals of the two periods have similar characters, while in the latter they are dissimilar. To account for the complex structures of the acid

rocks, he has recourse to the *agents minéralisateurs* to which French petrologists from the time of Élie de Beaumont have attached so much importance.[1] He ascribes all the differences of structure that can arise from a magma of given composition to variations in the three factors, temperature, pressure, and 'mineralisers,' and considers that in the structure of the basic rocks the first of these factors has had a dominant influence. Indeed he seems to imply that the order of crystallization of the constituents of these rocks depends in general on their relative fusibility, the initial temperature of the magma, and its successive more or less sudden variations. In this connection he cites the synthetic experiments of M. Fouqué and himself, which perhaps have not received due appreciation at the hands of geologists in general.

Our author strenuously denies the generality of the rule which associates the granitoid types of structure with deep-seated igneous rocks and the porphyritic and allied types with extravasated products, and quotes a number of instances in opposition to it. The citation of the Tertiary gabbro 'domes' of the Hebrides as analogous to the *puys* of Auvergne seems to rest on a misunderstanding of Dr. Geikie's description, and in any case the exceptional occurrences mentioned are scarcely sufficient to overthrow so general a law.

The second chapter is devoted mainly to a discussion of the minute structures of rocks and a comparison of the French and German views of the nature of 'petrosilex,' and the various centric and spherulitic structures of the acid series. From the concluding remarks we gather that the author definitively abandons the age, or presumed age, of igneous rocks as a principle of classification, and his observations in this connection will certainly commend themselves to English petrologists.

In the next chapter M. Michel Lévy considers the mineralogical constitution of igneous rocks, especially as an exponent of their chemical composition. He shows that by selecting as a basis of classification of the porphyritic rocks the elements of the first period of consolidation Rosenbusch has been led into a scheme of arrangement which accords but very imperfectly with the bulk-analyses of the rocks. He prefers to take account more particularly of the dominant 'white' (*i.e.* non-ferriferous) constituents of the second period of consolidation, which afford a more accurate index of the chemical composition of the rock. To elucidate his views he introduces a system of formulæ designed to express at once the structure of a rock, its mineral constituents, their order of consolidation, and their division into two periods of consolidation.

In the fourth chapter we have a detailed study of Rosenbusch's classification of eruptive rocks, and the artificial character of some of his divisions is clearly exhibited. Our author further taxes the leader of the German school with altering the meaning of well-established descriptive terms and often overlooking the prior claims of the nomenclature proposed by French petrologists, and it is impossible to deny that this protest is in many instances a just one.

While all geologists will sympathize with M. Michel Lévy's desire

[1] Cf. de Lapparent, Bul. Soc. Géol. Fr. (3) xvii. p. 282; 1889.

for a classification of igneous rocks which shall be *natural* and so independent of all hypotheses, many will doubt whether such a system is yet possible. Any well-established facts connecting particular types of rocks with special modes of occurrence, depths of consolidation, or even succession in geological time or restriction within 'petrographical provinces,' might well claim to be taken into account in a natural classification; but are geologists agreed on any of these points? M. Michel Lévy replies in the negative. The Wernerian heresy, from which the German petrologists have not yet fully recovered, had it been true, would have afforded an impregnable system of classification. Other systems, such as von Richthofen's 'natural classification of volcanic rocks,' have been founded on a similar assumed generality of a local succession. If future researches should bring to light general principles which will stand the test of particular applications, petrology will certainly be placed on a more philosophical footing. Meanwhile a classification like that of our author, founded on mineralogical and structural characters, the ultimate causes of which are only vaguely foreshadowed, cannot, however useful, claim to be a natural one.

The author is of opinion that the mode of occurrence of eruptive rocks is not sufficiently closely connected with their structure to be taken into account in a rational classification; but when he attacks the current division between plutonic and volcanic rocks, his position is seriously weakened by his admission that such a grouping agrees in the main with his own, founded on purely structural characters. Again, the intermediate class of 'dyke-rocks,' to which he also objects, appears in practice to be a very convenient one. Whether its limits, as defined by Rosenbusch, are well chosen, is a different question. Doubtless some geologists would prefer to include in it the diabases, which, as structurally distinguished from the dolerites, are characteristically found in dykes, sills, and small laccolites: others, with M. Michel Lévy, would exclude some of the so-called acid *ganggesteine*.

Our author expresses a hope that his somewhat *bizarre* symbolic notation may serve to bridge over the gap pending a unification of petrological nomenclature; but it appears a little complex and very likely to suffer in hasty writing, and it may be doubted whether it will commend itself to the geologist any more than to the printer. In the tabular exposition of the classification of Fouqué and Lévy, however, it gives a degree of precision which would not otherwise be attainable without lengthy descriptions. A. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Dec. 18, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Occurrence of the Genus *Girvanella*, and remarks on Oolitic Structure," By E. Wethered, Esq., F.G.S.

The author referred to his previous work, wherein he had shown

that *Girvanella* is not confined to Silurian rocks, and that as a rock-forming organism it is more important than was supposed, occurring in the Gloucestershire Pea-grit, and also in the Coralline Oolite of Weymouth. He now dealt more in detail with its occurrence (1) in the *Carboniferous Oolitic Limestone*; and (2) in the *Jurassic Oolites*.

In the Carboniferous Limestone of the Avon valley, oolitic limestone occurs on four horizons, in three of which the oolites rest on dolomite. In none of these three cases are there signs of *Girvanella*. From beds partly oolitic, and not resting on dolomite, he has been able to determine two new species. The oolite not associated with dolomite is less crystalline, and the original structure is better preserved.

In referring to *G. pisolitica*, he discussed whether *Girvanella* is most allied to the "Challenger" Foraminifer, *Hyperammina vagans*, or to *Syringammina fragilissima*. Traces of the organism occur in the *Clypeus*-grit, but none are quoted from the beds of the Great Oolite, nor from the Portland Oolite. The author had already shown that the pisolites in the Coralline Oolite of Weymouth were not concretions, but forms of *Girvanella*. Excluding these, he showed that the spherules are of four types, of which one is the ordinary oolitic granule, while each of the others suggests the presence of *Girvanella*.

The characters of the genus, as seen under the microscope, were indicated, and four new species were described.

2. "On the Relation of the Westleton Beds or 'Pebbly Sands' of Suffolk to those of Norfolk, and on their extension inland, with some observations on the Period of the final Elevation and Denudation of the Weald and of the Thames Valley." Part II. By Prof. Joseph Prestwich, M.A., D.C.L., F.R.S., F.G.S.

The author having, in the first part of this paper,[1] discussed the relationship of the Westleton Beds to the Crag Series and to the Glacial Deposits, proceeded in the present contribution to consider the extension of the Westleton Beds beyond the area of the Crag, and described their range inland through Suffolk, East, West, and South Essex, Middlesex, North and South Hertfordshire, South Buckinghamshire, and North and South Berkshire, noticing their relationship to the overlying Glacial beds, where these were developed, and the manner in which they reposed upon older deposits. He gave an account of the heights of the various exposures above Ordnance Datum, and mentioned the relative proportion of the different constituents in various sections, thus showing that in their southerly and westerly extension they differed both in composition and in mode of distribution from the Glacial deposits. Distinction was also made between the Westleton Beds and the Brentwood Beds.

Attention was next directed to the occurrence of the Westleton Series south of the Thames, in Kent, Surrey, and Hampshire, and their possible extension into Somersetshire was inferred from the character of the deposits on Kingsdown and near Clevedon.

In tracing the deposits from the east coast to the Berkshire

[1] Proc. Geol. Soc. June 5, 1889.

Downs, it was noticed that at the former place the beds lay at sea-level, but ranging inland, they gradually rose to heights of from 500 to 600 feet; that in the first instance they underlay all the Glacial deposits, and in the second they rose high above them, and their seeming subordination to the Glacial series altogether disappeared; thus at Braintree, where the Westleton Beds were largely developed, they stood up through the Boulder-clay and gravel which wrapped round their base, whilst further west, where they became diminished to mere shingle-beds, they attained heights of from 350 to 400 feet, capping London-clay hills, where the Boulder-clay lay from 80 to 100 feet lower down the slopes, the difference of level between the two deposits becoming still greater in a westerly direction, until finally the Boulder-clay disappeared.

The origin of the component pebbles of the beds was discussed, and their derivation traced (1) to the beds of Woolwich age in Kent, N. France and Belgium, and possibly to some Diestian beds, (2) to the older rocks of the Ardennes, (3) to the Chalk and older drifts, and (4) to the Lower Greensand of Kent and Surrey, or in part to the Southern drift.

The marine nature of the beds was inferred from the included fossils of the type-area, and the absence of these elsewhere accounted for by decalcification.

The southward extension of the beds was shown to be limited by the anticlinal of the Ardennes and the Weald, and the scanty palæontological evidence of the nature of that land was noted, and the possible existence of the Scandinavian ice-sheet to the north was referred to in connexion with the disappearance of the beds in that direction.

From the uniform character of the Westleton shingles the author maintained that they must originally have been formed on a comparatively level sea-floor, and that the inequalities in distribution had been produced by subsequent differential movement to the extent of 500 feet or more to the north and west above that experienced to the east and south, where the chronological succession remained unbroken, also that the inequalities below the level of the Westleton beds had been produced since the period of their deposition, as, for instance, the gorge of the Thames at Pangbourne and Goring, and most of the Preglacial valleys in the district; furthermore, evidence was adduced in favour of the formation of the escarpments of the Chalk and Oolites since Westleton times, whilst certain observations supplied data for estimation of the relative amounts of pre- and post-glacial denudation of the valleys.

It was stated, in conclusion, that the time for the vast amount of denudation was so limited that it was not easy to realize that such limits could suffice, but the author did not see how the conclusions which he had arrived at could well be avoided.

II.—January 8, 1890.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On some British Jurassic Fish-remains referable to the Genera *Eurycormus* and *Hypsocormus*." By A. Smith Woodward, F.G.S.

Hitherto our knowledge of the Upper Jurassic Fish-fauna has been mainly derived from specimens found in fine lithographic stones, where the various elements are in a state of extreme compression. Within the last few years remains of similar fish have been discovered in the Oxford and Kimeridge Clays in England, and these are of value for precise determination of certain skeletal features in the genera to which they belong.

The author described *Eurycormus grandis* from the Kimeridge Clay at Ely, a large species which makes known for the first time the form and proportions of several of the head-bones in this genus. A technical description of all the bones the characters of which are distinguishable was given, and the author concluded that there is considerable similarity between the head of *Eurycormus* and the recent Ganoid *Amia*, even to minute points of detail.

He further described *Hypsocormus tenuirostris* and *H. Leedsii* from the Oxford Clay of the neighbourhood of Peterboro', the osteology of this genus not having as yet been elucidated. Portions of the jaws have been discovered, affording valuable information as to the form and dentition of the principal elements.

These jaws are not precisely paralleled by any other Jurassic genus, though they possess a resemblance to *Pachycormus*, as also to the Upper Cretaceous genus, *Protosphyræna*.

2. "On the Pebidian Volcanic Series of St. Davids." By Prof. C. Lloyd Morgan, F.G.S.

The Relation of Pebidian to Cambrian.—There are four localities where the junction is described—Caerbwdy Valley, St. Non's Bay, Ogof Golchfa, and Ramsey Sound. The stratigraphy of the second of these was given with much detail, and illustrated. The author concluded that here, together with clear signs of local or contemporaneous erosion, the general parallelism of the strike of Pebidian and Cambrian is most marked. There is no evidence of any bending round of the conglomerate against the strike of the Pebidians. The stratigraphical evidence in each of the localities having been considered, together with the evidence offered by the materials of the Cambrian conglomerate and local interstratification with the volcanic beds (the interdigitation at Carnarwig being well marked), he concluded that there was no great break between the conglomerate and the underlying Pebidians. The uppermost Pebidian already foreshadowed the sedimentary conditions of the Harlech strata, and the change emphasized by the conglomerate was one that followed volcanic conditions after no great lapse of time.

Hence the relation of the Pebidian to the Cambrian is that of a volcanic series, for the most part submarine, to succeeding sedimentary strata—these strata being introduced by a conglomerate formed in the main of foreign pebbles borne onward by a current which swept the surface of, and eroded channels in the volcanic tuffs and other deposits. He was disposed to retain the name Pebidian as a volcanic series in the base of the Cambrian system.

The Pebidian Succession.—With the exception of some cinder-beds, which appear to be subaerial, the whole series was accumulated

under water. There is no justification for making separate subdivisions; the series consists of alternating beds of tuff of varying colour and basicity, the prevailing tints being dark green, red-grey, and light sea-green. In the upper beds there is an increasing amount of sedimentary material, and more rounded pebbles are found. Basic lava-flows occur, for the most part, in the upper beds. Detailed work, laid down on the 6-inch Ordnance Map, appears to establish a series of three folds—a northern anticline, a central syncline, and a southern anticline—folded over to form an isocline, with reversed dips to the S.E. The axis of folding is roughly parallel to the axis of St. David's promontory. The total thickness is from 1200 to 1500 feet. The author had failed to find the alleged Cambrian overlap. "The probabilities are that it is by step-faults between Rhoson and Porth Sele, and not by overlap, that the displacement of the conglomerate has there been effected." Also at Ogof Gôch it does not rest upon the quartz-felsite breccia and sheets (group C of Dr. Hicks), but is faulted against them. A section was devoted to the felsitic dykes, and it was suggested that they may be volcanic dykes of Cambrian age.

The Relation of the Pebidian to the Dimetian.—The author has not been able to satisfy himself of the existence of the Arvonian as a separate and distinct system. He notes the junction of Pebidian and Dimetian in Porthlisky Bay and the Allen Valley at Porth Clais, at neither of which places are there satisfactory evidences of intrusion. At Ogof Llesugn the intrusive character of the Dimetian was strongly impressed upon him. He criticized the mapping of Dr. Hicks, and pointed out the difficulties which present themselves in the way of mapping the Dimetian ridge as Pre-Cambrian. He pointed out that not a single pebble of Dimetian rock, such as those now lying on the beach in Porthlisky Bay, is to be found in the conglomerate. He concluded that the Dimetian is intrusive in the southern limb of the isocline, and that there are no Archæan rocks *in situ*.

OBITUARY.

EUGENE EUDES-DESLONGCHAMPS.

BORN 1830; DIED 1889.

We regret to have to record the death of M. Eugene Eudes-Deslongchamps, which occurred at Chateau Matthieu, Calvados, on the 21st of December, 1889. M. E. Eudes-Deslongchamps, who was born in 1830, early took an interest in scientific pursuits, and at the age of twenty-three joined the Linnean Society of Normandy, of which his father M. J. A. Eudes-Deslongchamps was one of the original founders; he became at once a regular contributor to the Society's Bulletin, and though he commenced work with ornithology, this group did not long monopolize his attention, his writings at this period dealing with Jurassic Geology, the Cirripedia, Mollusca, Brachiopoda, and an elaborate memoir on the Fossil Mammalia of Caen. In 1856 he published, in conjunction with his father, a French translation of the Introduction to Davidson's British Fossil

Brachiopoda. About this time he accepted the chair of Zoology at the Faculté des Sciences of Caen, with which institution he was connected for many years, and he subsequently became in addition Professor of Geology and Dean in 1861. His work had already secured for him a wide reputation both at home and abroad, and he was elected Correspondent of the Institut and Corresponding Member of the Society of Naturalists of Moscow and of the Geological Society of London. In 1863 he was appointed Secretary of the Linnean Society of Normandy, a post which he held till 1867, after which he served for a year as Corresponding Secretary.

In 1864 he published as a Doctoral Thesis his greatest stratigraphical work, "Études sur les étages Jurassiques inférieurs de la Normandie"; in the same year, the best results of his zoological researches were issued in his "Recherches sur l'organisation du Manteau chez les Brachiopodes Articulés," to the application of which to the classification of the group he frequently returned, but which he did not live to complete.

After his father's death in 1867, the younger Eudes-Deslongchamps devoted himself to the completion of the researches of the former on the Teleosaurs; his "Prodrome des Téléosauriens du Calvados" was probably his most important contribution to science, as it has formed the basis of all subsequent work on that family, and the genera *Metriorhynchus*, *Teleidosaurus*, *Pelagosaurus*, and *Steneosaurus* were either founded or first really defined in it. During the next ten years Eudes-Deslongchamps was at work on various subjects, and a list of papers on the recent and fossil mollusca of Normandy, the Brachiopods, the Cetacea, the Teleosaurians, with some botanical work, shows the wide range of his interests. He began also "Le Jura Normand," of which, however, only a few numbers were issued. A visit to the Brighton Aquarium, when that institution was at its best, inspired Eudes-Deslongchamps to agitate for the establishment of the Zoological station and laboratory at Luc-sur-Mer; he was director of this for some years, and in connection with it, did much good dredging work in the Channel, in his yacht, the "Emma."

In 1878 he resumed his connection with the Linnean Society of Normandy, and was in the same year elected to the Presidency, a post to which he was again called in 1886.

M. Eugene Eudes-Deslongchamps was perhaps one of the last of the old school of all-round naturalists; as was necessary for one who had devoted his life to the study of the whole natural history of so varied and extensive a country as Normandy, he was by turn botanist, zoologist, geologist, and archæologist; he was always ready to investigate whatever problem turned up next, and he seemed equally pleased to tackle deformed Fuchsias or Jurassic Crocodiles, Brachiopod histology or the correlation of the French Jurassics—any subject in fact that was connected with his beloved Normandy. Amongst the scientific workers of that province he can ill be spared, and the death of a naturalist of such wide and varied experience will cause a gap in the Linnean Society of Normandy that it will be difficult, if not impossible, to fill.